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OPERATIVE SURGERY

BY VARIOUS AUTHORS

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PREFACE TO THIRD EDITION

In this volume we have tried to meet the requirements of senior students and of young graduates who are engaged in surgical work in hospital. It may be helpful also to those preparing for higher surgical diplomas as a basis for further reading. The operations chosen for detailed description are those most favoured by the contributors, and the text may therefore be taken in a general way to represent the present-day practice of the Edinburgh School. Limitation of space alone prevents alternative methods being described in detail.

To bring this Edition into conformity with present-day practice, the text has been revised throughout, parts have been recast and rearranged, and some sections have been entirely rewritten.

An introductory chapter on *The Choice of Anaesthetic* has been added to obviate the necessity for repeated consideration of this matter apropos of individual operations. For a similar reason the chapter on *The Technique of Abdominal Surgery* has been recast and considerably amplified.

In the description of operations involving exposure of the main neurovascular bundles, the anatomical illustrations have been placed in relation to the *Operations on Blood-vessels*, and cross-references given to them in the chapter on *Operations on Peripheral Nerves*.

Modern practice in relation to *Amputation* of limbs has made it necessary to rewrite this chapter. In doing so we have to a large extent followed the teaching of Professor George Perkins and his co-workers at Queen Mary's Hospital, Roehampton, to whose published work we desire here gratefully to acknowledge our indebtedness.

The growing tendency towards specialization in surgery shown by the segregation of allied diseases and injuries in separate hospital clinics, with specially trained staffs of assistants and nurses, and specially designed appliances, has been markedly accelerated by experience gained in the late war. This trend has been most evident perhaps in relation to affections of the Central Nervous System. An adequate description of the diagnostic and operative technique employed in a modern Neuro-surgical Clinic would be beyond the needs of the general surgeon, and if not complete might be misleading. We have, therefore, decided not to include a description of operations on the central nervous system in this volume.

Once more we have gratefully to acknowledge the generous co-operation of our colleagues in the preparation of the text and in providing new illustrations. Their individual contributions are indicated on pp. vii and viii.

To Miss J. B. Gardner we are deeply indebted for the care and skill she devoted to the preparation of the manuscript for the press and to the revision of the proofs; and to Mr. Clifford Shepley for his valued co-operation in the designing and execution of many of the drawings.

We desire to acknowledge our indebtedness to Messrs Oliver and Boyd for permission to reproduce the following illustrations from the *Edinburgh Medical Journal*: Figs. 107–15, 118, 119, 174–8.

The Publishers, in the face of many difficulties, have again given us the generous assistance in the matter of illustrations and in other ways to which we have become accustomed in the volume.

January 1949.

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January 1949.

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CHAPTER 1

CHOICE OF ANAESTHETIC

General. Premedication and Basal Narcotics. Routes of Administration. Volatile Anaesthetics Gaseous Agents. Respiratory and Circulatory Failure. Endotracheal Methods. Local and Regional Analgesia. Curare.

The purpose of a chapter on anaesthesia in a book on operative surgery is not to provide detailed instruction, but rather to indicate the nature, scope, and limitations of the agents and procedures at present employed. Recent developments in anaesthesia and analgesia have facilitated the performance of operations of more extensive and intricate character than in the past when anaesthesia was limited to the administration of chloroform or ether, either on an open mask or in a simple closed inhaler. The introduction of agents of relatively low toxicity, and of apparatus which not only permits their quantitative delivery, but also provides when necessary effective control of pulmonary ventilation, ensures for patients a wide margin of immediate safety, and greater freedom from post-anaesthetic complications after major and prolonged operations, particularly those involving the viscera of the upper abdomen and thorax. Cyclopropane and the rapidly acting barbiturates are outstanding amongst the newer drugs, with *d*-tubocurarine chloride for the production of muscular relaxation

The adoption of apparatus for administering gases or vapours on the closed principle, with absorption of the patient's exhaled carbon dioxide by soda-lime granules, has brought particular refinement to inhalational anaesthesia. This technique provides the best conditions for the surgeon and a high standard of safety for the patient, even when there may be considerable interference with respiration and circulation. The great flexibility of control of the depth of anaesthesia which is possible can be increased by the use of endotracheal and endobronchial tubes in suitable cases.

A greater range of agents and methods is available for local and regional analgesia Among the latter are continuous spinal analgesia, epidural nerve block, caudal block, and refrigeration analgesia. Nerve block combined with some form of basal narcosis or light general anaesthesia is now receiving its long-deserved fuller recognition.

When the experience of the anaesthetist is limited, it is better to restrict general anaesthesia to giving ether on an open mask, or with an apparatus such as the Oxford vaporizer (p 6) The employment of nerve block (p 12) is a further advantage, especially if maximal

relaxation of muscle is required or if the operation is likely to be prolonged. As part of such a combined method, general anaesthesia need be at a depth only sufficient to maintain unconsciousness and immobility.

The more specialized character of anaesthetic practice has resulted in transference of responsibility for the welfare of the anaesthetized patient from the surgeon to the anaesthetist. There was a time when surgeons had ample opportunities as registrars or tutors to acquire experience in anaesthetics, but those days are gone. This is unfortunate because, for collaboration between the members of a team, the surgeon ought to have knowledge of and interest in the anaesthetic procedure. Knowledge need not be too technical, but it must include awareness of the potential dangers of modern anaesthetic methods, because of the difficulty of their detection by the inexperienced administrator or by the operator.

Although newer anaesthetic agents and methods have made protracted operations possible, this is no justification for dilatoriness in any surgical procedure. The maintenance of reasonable speed, so necessary when toxic drugs were used as anaesthetics, must not be wholly abandoned now. The benefits of modern anaesthesia must be preserved for the patient, for whom they were primarily intended and designed, and not neutralized by unnecessarily prolonging the operative procedure. A prolonged state of unconsciousness, even only a little more profound than sleep, is harmful to respiratory and circulatory efficiency.

Premedication and Basal Narcosis

The use of sedative drugs and basal narcotics before the administration of the anaesthetic proper has increased as less toxic anaesthetic agents have been introduced When chloroform was the usual anaesthetic, premedication was wisely limited to atropine; the vapour of chloroform can produce the deepest plane of anaesthesia without the aid of any preliminary sedative, indeed, after morphine the induction of anaesthesia by chloroform may be difficult and dangerous, because of the depression of the respiratory centre by the hypnotic. On the other hand, nitrous oxide gas is of such feeble anaesthetic potential that it must be preceded by a sedative drug and preferably one with analgesic properties, (e g morphine) unless the operation is short and on superficial tissues. Between the two extremes of nitrous oxide and chloroform the agents available and in common use vary in potency and, therefore, in the extent to which the synergistic use of drugs for premedication is advisable or safe During recent years there has been an unfortunate tendency to

excessive premedication. It is proper that the patient's pre-operative fears be adequately assessed and allayed but the drugs used for this purpose must never have a profound and prolonged effect continuing into the post-operative period. Of basal narcotics, a rapidly acting barbiturate such as thiopentone sodium injected intravenously is preferable to the slower- and longer-acting bromethol (avertin) given by the rectum. Prolonged unconsciousness with diminished reflexes is a major factor in producing post-operative respiratory and circulatory complications. It is a sound principle to contrive to have the effects of the anaesthetic mixture (i.e. the premedication plus the anaesthetic proper) finish as soon after the completion of the operation as possible.

The route of administration is an important factor in the effectiveness of premedication. Subcutaneous injection is the one most commonly chosen; it is the least dependable and the least predictable. In a patient suffering from peripheral circulatory failure, absorption of a drug such as morphine from the subcutaneous tissues may be very slow, and apparently so ineffective that unfortunately the dose may be repeated. With improvement in the peripheral circulation, absorption is likely to be accelerated and signs of over-dosage may appear; in the post-operative period these effects may prolong unnecessarily any depression of respiration and circulation due to the anaesthetic. When drugs are administered by the rectum, their time of maximal effect cannot be predicted, nor how long the effect will last.

Undoubtedly the most controllable and therefore safest route is the intravenous one, the direct path for rapid transmission to the central nervous system. Within the period of the circulation time (average 30 seconds) the action of a drug, injected intravenously, becomes increasingly obvious, and the dose appropriate to the patient's tolerance and requirements can be gauged accurately. Applied to pre-operative medication, the technique ensures certainty of effect, correct timing in relation to the anaesthetic proper, safety, and absence of such delayed action as frequently happens after subcutaneous or rectal doses. As an example: morphine gr. $\frac{1}{4}$ with hyoscine gr. $\frac{1}{100}$ may be given intravenously to a patient in bed immediately before he is transferred to the anaesthetic room; alternatively, it may be given in the anaesthetic room immediately before the general anaesthetic is begun The doses given are dissolved in sterile distilled water in a quantity (e g. 4 c.c.) suitable for a simple calculation of fractional dosage. The injection is given slowly, 1 c.c. in each 30 seconds, its effect being noted. When the patient becomes drowsy it is stopped; the point of optimal effect having been reached, no more drug is required.

If for any reason intravenous administration is not feasible, the intramuscular route should be selected; introduced in this way, sedatives become effective in from fifteen to twenty minutes.

Of the many drugs used for premedication, only the few in common use can be discussed here. *Whatever sedative is employed, it is* customary and usually advantageous to administer *atropine* at or about the same time. Atropine is a metabolic stimulant, and partly counteracts the depressant and hypnotic action of drugs such as morphine. Its essential action is the prevention of excessive secretion from the upper part of the respiratory tract during general anaesthesia, the dose must be adjusted to the age of the patient. Atropine interferes with the heat-regulating mechanism, and therefore must be reduced in amount, or omitted altogether, for instance in high fever or in acute infective conditions associated with dehydration.

Morphine is a useful and commonly employed drug which is both analgesic and hypnotic Unfortunately it stimulates the vomiting centre, and about 25 per cent of those receiving morphine or one of its derivatives are made sick by it or suffer from nausea quite independently of the effect of any subsequent anaesthetic drug. The barbiturates are often preferable *Pheno-barbitone*, gr iij intramuscularly with *atropine* gr $\frac{1}{100}$, is very satisfactory before abdominal operations after which vomiting might be expected In hypnotic doses barbiturates have no analgesic effect and are valueless for pain either before or after operation. *Seconal*, gr. $\frac{1}{2}$ per stone of body-weight, with a maximum of gr iij, is a suitable alternative to pheno-barbitone, it may be given by mouth one hour before operation.

Premedication must always be considered as part of the anaesthetic prescription. It serves to allay nervousness, to diminish secretions, particularly in the bronchial tree and stomach, and to depress metabolic activity, so that anaesthesia can be maintained with a smaller concentration of the anaesthetic agent proper. These purposes can be more completely achieved by preliminary basal narcosis, the quantity and concentration of anaesthetic required after the rectal administration of paraldehyde or bromethol or the intravenous injection of thiopentone sodium being correspondingly reduced. Of these two methods, intravenous injection of the rapidly acting barbiturate is the one choice, because the drug is broken down and eliminated within a short period, usually before the end of the operation. Moreover loss of consciousness takes place rapidly without any struggling, this being an important advantage, particularly in patients with raised blood-pressure or high intracranial tension, such as is encountered in neuro-surgical work Unlike bromethol, chloroform, or ether, thiopentone sodium constricts the pial vessels, so that

during induction with it intracranial pressure is lowered, and some cerebral vascular disasters in the induction stage of anaesthesia may be avoided. However, intravenous barbiturates are not entirely safe, and their administration demands close observation and sound clinical judgement as well as technical skill. For instance, laryngeal spasm is a common incident during thiopentone narcosis; although not always avoidable, much can be done to prevent its occurrence, and to mitigate rather than aggravate it once it has been established. The sequence thiopentone→ether is one in which glottic spasm is liable to be produced if the change over to ether is sudden, or if the initial concentration of ether is too high. Again, the premature insertion of an airway, pharyngeal or endotracheal, is a common cause of obstructive spasm, and even too early application of cold spirit for skin preparation at the site of operation may reflexly produce this unfortunate effect. Measures to abolish this spasm must be taken immediately; while there is still space between the cords, even though it is small, oxygen under intermittent pressure must be administered to tide the patient over the difficult period when respiratory obstruction is severe The injection of thiopentone into an artery causes intense arterial spasm, thrombosis, and possibly gangrene. When the patient is conscious, the pain of arterial spasm will make him cry out, and attention is drawn to the site of injection, but warning will be absent if the patient is already anaesthetized and is given a further maintenance dose of the agent into an aberrant artery mistaken for a vein. Extravenous injection of thiobarbiturate may cause localized ischaemia and sloughing.

Particular care must be taken with elderly or 'shocked' patients. When the circulation time of the blood is increased, the onset of anaesthesia may be delayed and an overdose of the drug administered in the mistaken idea that the patient is resistant. The barbiturates are not contra-indicated in these patients, but the injection must be made slowly and the effects observed with great caution.

The desire to provide prolonged anaesthesia simply by intravenous barbiturates is understandable, but such a procedure is not advisable except for operations requiring only a light plane of anaesthesia. The maintenance of deep anaesthesia for upper abdominal operations by means of barbiturates alone for periods longer than one hour is associated with a high incidence of post-anaesthetic complications, acute pulmonary oedema being one of the most serious.

The scope of the rapidly acting intravenous barbiturates may be summarized as follows

(*a*) As basal narcotics, preliminary to general anaesthesia or in small repeated doses up to a total of one gramme to maintain sleep during operations under local or regional analgesia or to ensure

unconsciousness and insensitivity to pain when *d*-tubocurarine chloride is exhibited to produce muscular relaxation.

(*b*) As the sole anaesthetic for short operations up to twenty minutes' duration, or for longer operations, e.g. plastic or neurosurgical procedures in which the depth of anaesthesia need be only minimal. *It is important that good oxygenation be maintained during such anaesthesia*, the patient being connected to the anaesthetic apparatus for this purpose.

The Volatile Anaesthetics

Ether and chloroform are still the most potent drugs in use. They can produce the deepest plane of anaesthesia, and although this is desirable for certain operations, it is obtainable only at a price, payable by the patient in the post-operative period; the elimination of the drugs is slow, and the damage they may do to the lungs, liver, and kidneys is an adverse factor in the patient's recovery. When less toxic agents and apparatus are not available or the administrator is inexperienced in their use, dropping of *ether* on a Schimmelbusch or Ogston mask is safe and reasonably satisfactory. It is of benefit to the patient if a constant stream of oxygen is delivered under the mask, to compensate for the hypoxia which usually develops in the course of a prolonged operation. With the general adoption of apparatus, ether is usually given in a carrier stream of nitrous oxide gas and oxygen, but apart from the easy induction by nitrous oxide and oxygen alone, it is doubtful whether this mixture has any advantage over ether and air, with additional oxygen if necessary. On this principle, the Oxford vaporizer is an effective yet simple apparatus for the administration of ether and air in controlled concentration. Oxygen may be added if required. *Chloroform* is rarely if ever employed in clinics with modern equipment and trained anaesthetists. *Trichlorethylene*, a drug closely related chemically to chloroform, has been introduced and employed as a substitute for ether when an agent non-inflammable and non-irritating to the bronchial mucosa is required, it has a high boiling-point, 87° C (cf. chloroform 61° C. and ether 36° C.), and does not volatilize readily. Its analgesic action is noteworthy—a marked degree of insensitivity to painful stimuli is present while the patient is still conscious. When muscular relaxation is not required, but only insensitivity to pain, immobility, and unconsciousness, trichlorethylene has a certain sphere of usefulness. *Divinyl-ether* is an inflammable, very volatile, unstable, and rapidly eliminated agent which is useful in minor surgery, for instance as a single dose (3 c.c.–5 c.c.) for incision of abscess. *Chloride of ethyl* also is essentially a single-dose (3 c.c.–5 c.c.) anaesthetic, it may also be used for induction.

THE GASEOUS AGENTS

Nitrous oxide is practically non-toxic, but so far as any surgery requiring relaxation is concerned, nitrous oxide anaesthesia must be completely discounted. It provides a quick and easy induction to the stage of unconsciousness; a major anaesthetic agent such as ether can then be added. Minor operations of short duration may be performed under gas and oxygen alone, and this is useful in dealing with the ambulatory cases of an out-patient department. For any patient, but particularly the very young, the old, and the anaemic, nitrous oxide with too little oxygen is more dangerous than ether with plenty of oxygen. Furthermore, asphyxial anaesthesia produced by a combination of nitrous oxide and lack of oxygen may hinder the surgeon in his work particularly if he is dealing with a fracture, the patient will take longer to recover, and he will feel much more ill after this anoxaemia than he would after the administration of a more potent agent with adequate oxygenation. Nitrous oxide is frequently used to prolong a state of basal narcosis initially induced by an intravenous barbiturate, and with oxygen it may be employed to provide sleep for the patient while the operation is being performed under local or regional analgesia.

Cyclopropane has qualities which make it the most effective, safest, and least detrimental of the inhalational agents employed for general anaesthesia It is easily inhaled, and when properly administered is sufficiently potent to give adequate relaxation even for operations in the upper abdomen. It is readily eliminated, so that reflex activity and consciousness return quickly even after a prolonged operation. The surgeon must know of two important features of cyclopropane anaesthesia:

(1) The quietness of the respiration under cyclopropane anaesthesia is marked

(2) In many patients depression of the respiratory centre accompanied by decreasing amplitude in the pulmonary excursion and finally apnoea take place before anaesthesia is deep enough to provide adequate relaxation of the abdominal muscles. During this period the pulse is of good quality and slow. So long as adequate ventilation is carried out, cardiac action will remain unimpaired, but if an efficient pulmonary exchange is not maintained, cardiac arrhythmias may develop During cyclopropane anaesthesia it is helpful if the surgeon will start to operate at the stage when the respiratory excursion is getting smaller and before full relaxation of muscles has been reached. The sensory stimulation thus applied increases the depth of respiration and the patient then inhales sufficient gas to anaesthetize him to the extent necessary, without the anaesthetist having recourse to 'assisted' or 'controlled' respiration. The elasticity of control which

can be exercised by the anaesthetist over respiration and oxygenation has made cyclopropane the first choice for intrathoracic operations. During thoracotomy paradoxical breathing can be eliminated and mediastinal movement damped down by the production of apnoea, and by gentle inflation of the lungs according to the patient's needs and at times which will not inconvenience the operator: movements of the diaphragm may also be assisted by these manœuvres. In ill patients in whom it is desirable to avoid deep anaesthesia, reduction of respiratory movements is a reasonable substitute for profound muscular relaxation. Cyclopropane is inflammable and therefore diathermy must not be used on structures within the pleural cavity when the patient is anaesthetized with this gas.

Apart from its general excellence as an anaesthetic for all forms of major surgery, cyclopropane provides satisfactory basal narcosis in cases in which the operation is performed under local or regional analgesia For this purpose it is more suitable than nitrous oxide because it provides a wider margin between sleeping and waking, and it can be used with plenty of oxygen As a short anaesthetic for

activities in an hour or so.

Closed-circuit Technique—Apparatus incorporating the principle of carbon dioxide absorption by soda lime provides many refinements in the technique of inhalational anaesthesia Over-zealous ventilation through soda lime at the end of an operation may produce alkalosis and a degree of hypoxia, indicated by very shallow breathing, rapid pulse, and low blood-pressure. This serious development, which is due entirely to bad anaesthetic technique, is frequently and erroneously attributed to the surgical procedure Ventilation at the end of the operation should be performed with the soda-lime canister cut out, and when deep spontaneous respiration is established, a change over from oxygen to air ought to be made. During closed-circuit anaesthesia the alveoli contain a high percentage of absorbable gases or vapours such as cyclopropane, or ether and oxygen, and the inert diluent nitrogen is present in less than normal amount It is important to restore as quickly as possible the normal physiological content of the air cells, otherwise collapse of lobules of the lung is a likely development if bronchioles become plugged with mucus Oxygen or cyclopropane is absorbed from a 'closed' lung lobule in twenty to thirty minutes, and the lobule will then collapse On the other hand, air in an isolated lobule of lung will be absorbed only after thirty-six hours Such an interval gives a patient time to open up the bronchiole by coughing out the plug of mucus

Respiratory and Circulatory Failure

During operations under general anaesthesia respiratory or circulatory failure may occur. Except in cases of avoidable mechanical obstruction or of apnoea purposely produced by the anaesthetist, respiratory arrest is due to an overdose, actual or relative, of the anaesthetic agent. The prevention of this is a matter primarily for the administrator who must by continuous close observation of the patient anticipate any serious development. In addition to proper regulation of the level of anaesthesia, this involves the recognition and assessment of significant surgical factors such as haemorrhage and sensory stimulation. These may quickly produce circulatory changes which upset the balance between absorption and elimination of the anaesthetic agent, and relative overdosage will result. Correction of respiratory arrest must be initiated at once with the following measures:

(1) Stop the anaesthetic.
(2) Ventilate the lungs by rhythmic inflation fifteen times per minute, using for the purpose the rebreathing-bag of the anaesthetic apparatus, a face mask, and oxygen.
(3) Lower the head of the table.

The Sylvester method of artificial respiration is much less effective because the tidal exchange is considerably smaller, but in the absence of apparatus it may have to be employed.

Circulatory failure is a much more serious matter and the time in which such a development can be successfully overcome is very short indeed. Primary cardiac failure due to the inhalation of an anaesthetic vapour is seen only during induction with chloroform or chloride of ethyl. If the radial pulse is present, hyperventilation of the lungs with the patient in the Trendelenburg position may avert disaster. If the heart has already stopped, cardiac massage is the only measure which has any chance of success, but it must be carried out immediately, that is to say, within one minute. Injection of drugs is useless, but stimulation of the right auricle by means of a long needle inserted downwards and inwards through the third right intercostal space close to the sternum is reputed to have been successful in starting cardiac contraction.

The more common type of circulatory failure is that which may arise in the course of a severe or long operation. There are always adequate clinical signs to warn the surgeon and anaesthetist of impending failure, and treatment must be directed to mitigation of the contributory causes. Replacement of blood lost and elimination of the anaesthetic by ventilation of the lungs with oxygen are the main items in resuscitation. The heart that stops because such

can be exercised by the anaesthetist over respiration and oxygenation has made cyclopropane the first choice for intrathoracic operations. During thoracotomy paradoxical breathing can be eliminated and mediastinal movement damped down by the production of apnoea, and by gentle inflation of the lungs according to the patient's needs and at times which will not inconvenience the operator; movements of the diaphragm may also be assisted by these manœuvres In ill patients in whom it is desirable to avoid deep anaesthesia, reduction of respiratory movements is a reasonable substitute for profound muscular relaxation. Cyclopropane is inflammable and therefore diathermy must not be used on structures within the pleural cavity when the patient is anaesthetized with this gas.

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Closed-circuit Technique —Apparatus incorporating the principle of carbon dioxide absorption by soda lime provides many refinements in the technique of inhalational anaesthesia. Over-zealous ventilation [illegible] produce alkalosis [illegible] w breathing, rapid [illegible] ment, which is due entirely to bad anaesthetic technique, is frequently and erroneously attributed to the surgical procedure Ventilation at the end of the operation should be performed with the soda-lime canister cut out, and when deep spontaneous respiration is established, a change over from oxygen to air ought to be made During closed-circuit anaesthesia the alveoli contain a high percentage of absorbable gases or vapours such as cyclopropane, or ether and oxygen, and the inert diluent nitrogen is present in less than normal amount It is important to restore as quickly as possible the normal physiological content of the air cells, otherwise collapse of lobules of the lung is a likely development if bronchioles become plugged with mucus Oxygen or cyclopropane is absorbed from a 'closed' lung lobule in twenty to thirty minutes, and the lobule will then collapse On the other hand, air in an isolated lobule of lung will be absorbed only after thirty-six hours. Such an interval gives a patient time to open up the bronchiole by coughing out the plug of mucus.

the nose, posterior pharyngeal wall, and entrance to the larynx, which may follow clumsy and unintelligent attempts. There are two routes by which a tube may be passed into the trachea—the nasal and the oral. Nasal intubation is justifiable only when the site of operation is within the mouth, and in certain cases in which the position of the patient during operation renders fixation of a tracheal tube difficult Thus, for an operation on the cerebellum a patient is placed face downwards with his head acutely flexed, and in this extreme position an oro-tracheal tube is apt to become kinked, or the adhesive plaster fixing it in position may be loosened by secretions from the pharynx and bronchial tree gravitating into the mouth and nose. A naso-tracheal tube can be fastened much more securely and is to be preferred in such cases. The chief objections to naso-tracheal intubation are:

(a) The frequent presence of sepsis in the nose, particularly antral infection and discharge, with the possibility of transference of pus to the trachea during passage of the tube.

(b) Trauma to the nasal mucosa causing bleeding from the turbinates or a deflected septum. Sometimes this may be very severe, but even if slight the blood collected in the tube may clot and cause obstruction to breathing. A more remote sequel is the formation of adhesions at the site of injury within the nose.

(c) Trauma to the vocal cords. Blind stabbing at the cords with a tracheal tube may initiate the development of a granuloma or cyst of one cord some weeks later.

(d) The size of the tube is limited by the width of the nostril, which in some instances is too narrow to accommodate a tube adequate for the patient's tidal air excursion If there is gross deformity from septal spurs and enlarged turbinates, a naso-tracheal tube may be so compressed as to be useless. In cases where nasal intubation is the only choice, attempts to pass the tube blindly must not be persisted in; the tube must be made to complete its journey through the glottis under direct vision, the anaesthetist employing a laryngoscope and forceps designed for the purpose.

Oral intubation should and can be an atraumatic procedure. The first requirement to ensure this is good relaxation of the jaw so that a laryngoscope may be introduced and the glottis exposed without the use of force If relaxation is inadequate, the risk of damage to the lips, teeth, and pharynx is real. A further advantage of oral intubation is that tubes of larger calibre than could be passed through the nostrils may be used. The possibility of trauma to the tracheal mucosa by the tip of the tube is less likely if vinyl-portex (plastic) tubes are employed, rather than those made of moulded rubber which retain their curvature. At body temperature a plastic tube will lie

measures have been instituted too late has stopped for good, and no amount of stimulation by drugs or massage can revive it.

Endotracheal Methods

In many of the operations of surgery administration of anaesthetic vapours or gases through a tube passed into the trachea is a valuable technique, but it should be employed only when necessary.

If general anaesthesia is being employed, there are certain positive indications for the endotracheal route.

1. *Operations on the head and neck.* for example, intracranial procedures, excision of glands of neck, thyroidectomy, operations in the mouth and oro-pharynx. By means of a tracheal tube a perfect airway can be maintained without any troublesome adjustment during the operation, and the anaesthetist can exercise remote control. The unconscious patient about to undergo operation for a head injury comes into this category, he ought to be intubated in order that insufflation of oxygen may be started if respiration becomes very depressed, or anaesthetic vapour given should consciousness be regained during cerebral decompression

2. *Operations in which the position of the patient on the table makes the maintenance of a good airway difficult*: laminectomy, nephrectomy.

3 *Operations within the thoracic cage.* the alterations in the dynamics of respiration and circulation which follow thoracotomy necessitate a technique of anaesthesia which will counteract them Paradoxical respiration and excessive mediastinal movement and displacement, occurring during intrathoracic operations, are physiological abnormalities of serious concern to both surgeon and anaesthetist. This advancing sphere of surgery has provided opportunities for the development of manœuvres such as 'controlled' and 'assisted' respiration, and of methods of excluding or isolating an affected lung or part thereof by means of gauze tamponage or the Thompson tube. Specially designed endotracheal and endobronchial tubes with inflatable cuffs for occlusion of trachea or bronchus may be used to convey the anaesthetic gas or vapour to the part of the lung still permitted to function.

4. *Difficult upper abdominal operations* for instance, closure of a duodenal perforation The tendency for intermittent glottic spasm to occur during the manipulation of the stomach and duodenum hinders efficient respiratory exchange, and the smooth anaesthesia necessary for dealing with this condition is best obtained when a wide-bored endotracheal tube is employed

Reference must be made to certain aspects of the technique of tracheal intubation on account of the difficulties and pitfalls associated with it, and the serious trauma to the mucous membrane of

the nose, posterior pharyngeal wall, and entrance to the larynx, which may follow clumsy and unintelligent attempts. There are two routes by which a tube may be passed into the trachea—the nasal and the oral. Nasal intubation is justifiable only when the site of operation is within the mouth, and in certain cases in which the position of the patient during operation renders fixation of a tracheal tube difficult. Thus, for an operation on the cerebellum a patient is placed face downwards with his head acutely flexed, and in this extreme position an oro-tracheal tube is apt to become kinked, or the adhesive plaster fixing it in position may be loosened by secretions from the pharynx and bronchial tree gravitating into the mouth and nose. A naso-tracheal tube can be fastened much more securely and is to be preferred in such cases. The chief objections to naso-tracheal intubation are:

(*a*) The frequent presence of sepsis in the nose, particularly antral infection and discharge, with the possibility of transference of pus to the trachea during passage of the tube.

(*b*) Trauma to the nasal mucosa causing bleeding from the turbinates or a deflected septum. Sometimes this may be very severe, but even if slight the blood collected in the tube may clot and cause obstruction to breathing. A more remote sequel is the formation of adhesions at the site of injury within the nose.

(*c*) Trauma to the vocal cords. Blind stabbing at the cords with a tracheal tube may initiate the development of a granuloma or cyst of one cord some weeks later.

(*d*) The size of the tube is limited by the width of the nostril, which in some instances is too narrow to accommodate a tube adequate for the patient's tidal air excursion. If there is gross deformity from septal spurs and enlarged turbinates, a naso-tracheal tube may be so compressed as to be useless. In cases where nasal intubation is the only choice, attempts to pass the tube blindly must not be persisted in; the tube must be made to complete its journey through the glottis under direct vision, the anaesthetist employing a laryngoscope and forceps designed for the purpose.

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straight in the trachea. Tracheal tubes with inflatable cuffs ought to be passed under direct vision. Endobronchial tubes require a special bronchoscopic cannula (Magill) for their introduction.

Certain less easily recognized dangers arising from endotracheal anaesthesia are worthy of note by the surgeon as well as by the anaesthetist.

1 The serious situation of the patient in whom an extra long endotracheal tube has been employed. An inexperienced anaesthetist may use a tube (as supplied by the manufacturers) which is much too long and which when passed extends beyond the bifurcation of the trachea into one or other bronchus—usually the right which is in a more direct line with the trachea than the left. In the right bronchus the tube may easily occlude the opening of the right upper lobe bronchus. The patient in whom this has happened will become cyanosed, even when apparently having plenty of oxygen, because the lobe of the lung behind the occluded bronchus does not function and is likely to collapse in a short time.

2. The effects of by-passing the nose. Nature's air-conditioning apparatus, the nose, is rendered ineffective when the whole volume of the patient's tidal air passes in and out of the lungs through a tracheal tube, the mucosa of the upper part of the respiratory tract becomes dry and a slight degree of narrowing of the bronchi and bronchioles may result. This effect is aggravated when nitrous oxide, oxygen, and ether are delivered through a tracheal tube at a high rate of flow, from a continuous flow apparatus such as that of Boyle, and this method, as might be expected, is followed by a higher incidence of respiratory complications than most others, including 'open' ether. On the other hand, the use of the closed-circuit technique, which reduces the loss of heat and moisture, will prevent, or at least mitigate, this adverse factor.

Local and Regional Analgesia

Nerve blocking by analgesic and paralysing drugs has a wide application in operative surgery, from the baby with congenital pyloric stenosis to the octogenarian with strangulated hernia The choice of a technique depends on conditions in the field of operation such as the situation and size of the lesion, and the presence or absence of sepsis Because of the limitation of the analgesic agent to the area being operated upon, local methods are much less toxic than general anaesthesia in which generalized intoxication of the tissue cells of the body is unavoidable. For this reason and because of the additional advantages of localized ischaemia and interruption of sensory stimuli, nerve block is the method of choice in the very ill patient

It is not always possible or advisable to employ it while the patient remains conscious; allowance must be made for his desire to be unconscious while in the operating theatre. Adequate premedication or basal narcosis, particularly by means of barbiturates which have the advantage of raising the minimal lethal concentration of drugs used for local or regional analgesia, is essential in all cases except in infants. The advantage is not only to the patient; there is probably less strain on the operator if the patient is quietly asleep.

Planned nerve block must be completely effective. For minor surgery, this is easy to achieve by local infiltration, but in the surgery of the abdomen, especially in obese subjects, the more complicated techniques of paravertebral and intercostal block can be difficult, and for satisfactory results much experience is required. There must be no haphazard or perfunctory technique, with the thought that any deficiencies may be covered up by rendering the patient unconscious by intravenous thiopentone sodium or by an inhalational agent such as cyclopropane. The analgesia produced ought to be sufficient in itself to meet the requirements of both surgeon and patient, and its effectiveness must be independent of the basal narcosis which is employed to eliminate psychical factors. Nerve block of the area of operation must produce motor as well as sensory paralysis; for example, in abdominal surgery infiltration of the line of incision and of the recti muscles may produce insensitiveness and relaxation of those muscles, yet the abdomen may still be 'tight' because the flat transversus abdominis muscles and their tendinous expansions which form the sheath of the rectus are not paralysed by infiltration in the line of the incision. To overcome this difficulty, the intercostal nerves must be blocked at points no farther anteriorly than the mid-axillary line, otherwise deep supplementary general anaesthesia will be required to provide relaxation and the patient will be little better off than if the attempt to block the nerves had not been made.

Spinal block analgesia provides operating conditions which, from the point of view of the surgeon, can hardly be excelled. In abdominal surgery relaxation of the wall of the abdomen, minimal bleeding, and contracted bowel are advantages of this method. Because of the lowered blood-pressure, haemostasis must be meticulous, otherwise reactionary hemorrhage may occur after the effects of the spinal block have passed. Whilst it can be used for upper abdominal operations and even for some thoracic interventions, for certain operations in the thorax its employment is inadvisable because of the high incidence of respiratory and circulatory sequelae. In subarachnoid blocks above the level of the fifth thoracic segment the fall of blood-pressure may become extreme and require skilled management. High blocks also eliminate the intercostal muscles for the time being

as factors in respiration, and the inadequate oxygenation which results, combined with the reduced cardiac output, will ultimately lead to cerebral anaemia and depression of the medullary centres. It is imperative, therefore, that the anaesthetist, while providing optimal operating conditions for the surgeon by means of spinal or extensive paravertebral block, must also provide means to counteract the detrimental features of the method. Oxygen should be given throughout the operation, and it is an added advantage if the patient is kept in a state of unconsciousness by the addition of a little nitrous oxide to the oxygen.

D-tubocurarine Chloride.—The recent introduction of *d*-tubocurarine chloride as an adjuvant in anaesthesia has threatened the position of spinal block, with its risks of infection, of spinal damage, and of medullary depression. This drug acts primarily on the myoneural junctions in all voluntary muscles. When injected intravenously, it produces in two or three minutes relaxation of the entire musculature of the body. The degree of relaxation is dependent on the amount of the drug injected When carefully administered, good relaxation for upper abdominal surgery is produced without too marked an effect on the intercostal muscles, when larger doses are given, the latter may be paralysed. This should be avoided, because respiration must be maintained entirely by the diaphragm and as a consequence becomes jerky in character and hinders the work of the surgeon. In still greater overdosage the diaphragm itself may become paralysed and asphyxia is then an imminent danger. The admini-

an hour—as is required for the detoxication of the drug and for its elimination. There is no reason for stopping the operation while such a condition persists After administration of *d*-tubocurarine chloride the blood-pressure does not fall, as it may do in spinal-block analgesia It is notable too that the drug appears to block the autonomic ganglia, for in cases in which much handling of viscera produces a fall in blood-pressure, the injection of *d*-tubocurarine chloride is followed by a restitution of blood-pressure to normal level If this be generally true, then this powerful agent has all the advantages of spinal analgesia in respect of the production of muscular relaxation and few or none of its disadvantages *D*-tubocurarine chloride has

sive because the lower jaw and tongue sag backwards and narrow

his airway. Therefore the administration of the drug must be accompanied by basal narcosis in order that the patient may not suffer pain or be aware of his helplessness during the surgical procedure. Local analgesia, while satisfying the factor of abolition of pain, is inadequate for the curarized patient because it does not eliminate the discomfort and nightmarish state which may be present. A simple combined technique which can be recommended from experience is the following. After suitable premedication the patient is given thiopentone sodium, 0·25 gm.–0·5 gm. intravenously. Light anaesthesia is then maintained by means of cyclopropane and oxygen. The effects of skin preparation and insertion of towel clips are observed as a preliminary test of insensitivity to pain. Finally, the presence or absence of reaction to the skin incision is noted and any necessary adjustment made in the amount of cyclopropane. The level of unconsciousness thus stabilized is easily controlled throughout the operation. While the surgeon is engaged in securing haemostasis in the superficial tissues and before he proceeds to incise the peritoneum, 15 mg.–20 mg. of *d*-tubocurarine chloride are injected intravenously; this produces the necessary muscular relaxation. In a long operation smaller additional doses of the agent may be required at intervals of 45–60 minutes.

Experience with *d*-tubocurarine chloride points to a wide sphere of usefulness in difficult surgery, for example, in excision of the head of pancreas, in gastrectomy, and in intrathoracic work. For poor-risk cases undergoing operations in these categories, it has greatly reduced the risk and enhanced the chances of success.

J. G.

CHAPTER II

OPERATIONS ON BLOOD-VESSELS

Injuries. Operations on Large Arteries Operations for Aneurysm. Transfusion of Blood. Operations on Veins. Operations on Individual Arteries

Injuries of Large Arteries

Experience in recent wars has added materially to our knowledge of localized injuries of large blood-vessels and of their surgical treatment. As a result of improved operative procedures, the extended use of blood transfusion, and the introduction of new antiseptics such as penicillin, the dangers of such injuries have been definitely reduced

Arterial Contusion results from blunt violence, or from a near miss by a missile of high velocity. The intima is most seriously damaged, thrombosis occurs and may be so extensive that the artery is completely occluded. In wounds of soft parts the artery may escape gross injury, but may be thrown into intense spasm by the passage of the missile through the tissues, and this may be so persistent that the peripheral circulation is gravely endangered.

In stab and gunshot wounds the artery may be *completely divided*; the ends of the vessel contract and retract and the intima curls up inside the lumen so that bleeding is slight If the vessel is only *partly divided* and the soft tissue wound is small or valvular, bleeding occurs into the tissues and an *arterial haematoma* forms, but the peripheral blood-flow is seldom completely interrupted In the absence of swelling and murmur in the vicinity of the wound, signs of interference with the peripheral circulation—pallor or cyanosis, coldness of the skin, and absence of the peripheral pulses—call for exploration.

Complications.—An *arterial haematoma* gives rise to a swelling in or near the anatomical line of the artery In the early stages it does not pulsate, but the peripheral pulses are diminished and a systolic murmur may be audible over the swelling. Operation is indicated if a large haematoma is pressing on the collateral vessels, if rapid enlargement of the haematoma occurs, if suppuration occurs at its periphery, or for severe pain which does not yield to sedatives. If the haematoma is not dealt with, the clot becomes organized and a *traumatic aneurysm* may form.

Secondary haemorrhage may occur from the giving way of the contused segment of the artery in the presence of wound sepsis, or from the erosion of the arterial wall from associated infective condi-

tions. Exploration is required to admit of the bleeding-point being secured.

Arteriography.—When the exact nature and site of the lesion cannot be determined by simpler means, the artery may be exposed under local or general anaesthesia, and 10 c.c. of a radio-opaque substance, such as perabrodil or pyelosil, introduced through a needle (size 19) with the bevel directed towards the lumen of the artery. The artery is disturbed as little as possible to avoid inducing arterial spasm. Exposure to X-rays is made as the injection is being completed.

Operations on Arteries

The objects of surgical intervention are to arrest haemorrhage, and to safeguard the nutrition of the territory supplied by the injured artery, by conserving as far as possible the collateral circulation. Resting muscle requires a relatively small blood-flow, but hard exercise makes great demands on the circulation. If the blood-flow through a main artery is slowly reduced over a period there is time for a collateral circulation to develop, and the alternative circulation may be so good that the impairment of the blood-flow is apparent only during hard exercise. If, on the other hand, the main arterial flow is cut off abruptly there is not time for branches to open up, and [illegible]

collateral circulation ultimately develops, it cannot reverse ischaemic changes already present. It is therefore the object of the surgeon to strive to maintain the flow of blood through an injured artery; should this prove impossible, he must endeavour to promote rapid development of a collateral circulation, and to place the area supplied by the vessel under the best conditions to minimize the effects of the ischaemia during the critical period when the collateral circulation is being developed.

It is necessary to control the flow through the artery while the manipulations are being carried out, either by a tourniquet, or by exposing the vessel proximal to the lesion and occluding it by a temporary ligature. This is conveniently done by a tape sling (Fig. 1) secured by light arterial clamps, or gentle traction may be made on the sling by an assistant Rubber tubing may be used in place of tape.

Methods.—According to the nature of the lesion in the wall of the artery, different measures are employed.

Ligation.—In large arteries, e g. the femoral, axillary, or common carotid, broad, strong material (braided silk or tape) is employed.

To avoid rupturing the intima, the segment of the artery involved should be emptied of blood by stripping it with the fingers, and the ligature should be tightened gradually.

Arteriorraphy.—Arterial suture is not always possible on account of the contused or lacerated condition of the vessel wall. After the vessel has been exposed, light clamps or temporary ligatures are applied above and below the wound in its wall, and the tourniquet is removed. Blood clot is removed from the wound with sterile 3·8

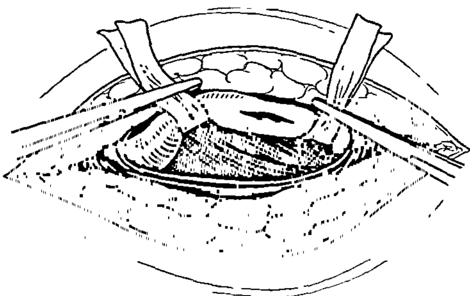


FIG. 1 Method of occluding Vessel temporarily by means of Tapes held by Artery Forceps

per cent. sodium citrate solution or heparin Fine silk mounted on atraumatic round-bodied needles is used

Lateral suture is applicable when there is no contusion or laceration of the edges of the artery, and when the wound is in the long axis of the vessel or involves not more than a third of its circumference The adventitia is removed from the edges, and stay sutures are inserted b

(Fig. 3).

using the

of the other. The distal clamp or temporary ligature is removed first, and then the proximal one is gradually relaxed Oozing from the suture line is controlled by steady pressure with a moist swab, or with a muscle graft.

End-to-end Anastomosis.—Circular arteriorrhaphy is indicated in clean-cut wounds with little or no contusion or laceration It is

essential that there should be no tension on the suture line; as mobilization of the artery may be limited by branches which fix it, and as arteries are incapable of stretching, suture is impossible if there has been much loss of substance. It can be carried out only in the absence of sepsis. Haemorrhage is controlled as in lateral suture.

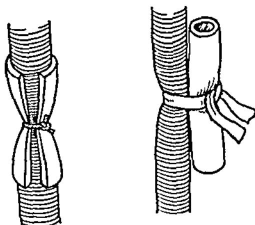


FIG. 2. Method of occluding Artery temporarily by means of ligature or tape tied over Rubber Tube.

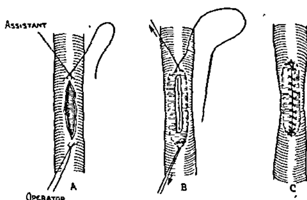


FIG 3 Steps in the Closure of a Longitudinal Wound of an Artery.

The wound is carefully cleansed, the arterial ends are freed for a distance of 5 cm. (2 in.), temporary ligatures are applied, and the tourniquet is removed. The arterial ends are then carefully surrounded with gauze moistened with sodium citrate solution and trimmed neatly and evenly. The adventitia is drawn as a cuff over each arterial end by pinching the vessel between finger and thumb, and removed with fine scissors The lumen of each end of the vessel is cleansed of clot, and kept moist with sodium citrate solution or

heparin throughout Instruments as they are used are washed in citrate solution before being used again. A stay suture is passed through the mid-points of the posterior walls of the two segments, and two further stay sutures are inserted equidistant from the first, thus triangulating the vessel The posterior suture is tied and a forceps attached to its short end while the other two are tied and secured by forceps at a distance of about 12 cm (5 in) from the artery. While traction is maintained a continuous suture is inserted, using the long

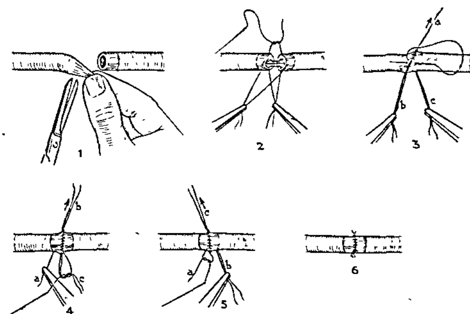


Fig. 4 Steps in the End-to-end Anastomosis of a Divided Artery.

end of the posterior stay suture, tying it to each stay suture in turn and completing the suture by tying it to its own short end (Fig. 4).

Restoration of the Arterial Lumen by Artificial Means—When there is considerable contusion or laceration of the arterial ends, or if it is difficult to mobilize the vessel sufficiently, other means of restoring the lumen are available. Glass or plastic tubes may be employed, they are tied into the arterial ends after these have been trimmed and cleansed, and heparinization is begun (p 21). Gradual diminution of blood-flow results, and this gives more time for the opening up of a collateral circulation. To be effective and safe the peripheral circulation should be restored rapidly, otherwise absorption of products of disordered metabolism from the ischaemic limb may lead to fulminating and even fatal toxaemia.

Vein grafts have the advantage that they may be left *in situ*. Segments of vein of suitable size may be joined to the arterial ends

by end-to-end anastomosis; this method was seldom successful before the use of anticoagulants because thrombosis was almost certain to occur at the double suture lines. Blakemore and his co-workers have evolved a 'no-suture vein graft' using small vitallium cannulas through which the ends of the graft are inserted and turned back over the outer surface of the cannulas. The graft is then introduced into the arterial ends and secured by ligatures. This method requires adequate operating facilities.

After-care.—The coagulation time is estimated by the capillary method, and heparinization is begun at the conclusion of the operation. Ten milligrams of heparin are made up in 100 c.c. of saline, and given through a fine needle into a small vein at the rate of 30 drops per minute. At first the coagulation time is estimated hourly, and the aim should be to keep it at about fifteen minutes; later four-hourly estimates of the coagulation time are made. Heparinization is continued for from seven to ten days until the danger of thrombosis is past.

Embolectomy.—When an embolus threatens the vitality of a limb, embolectomy should be performed without delay, provided the general condition of the patient justifies operation. The embolus usually comes from the left side of the heart and tends to be arrested at a point where the artery is narrowed by division, or by the origin of a large branch. The common femoral artery at the level of the profunda branch is the commonest site for the lodgement of an embolus in the lower limb, but any artery from the bifurcation of the aorta to the termination of the popliteal may be occluded. Embolism is less common in the upper limb. Surgical interference is usually indicated when an embolus is arrested in any part of the main artery above the level of the bifurcation of the popliteal or of the brachial artery, but is seldom required if the embolus is confined to one of the peripheral branches formed by the division of these vessels. If operation is delayed, a greater length of the vessel is occluded by thrombosis, which begins at the embolus and tends to spread mainly in a peripheral direction occluding both the continuation of the main vessel and the branch situated at the level of the embolus According to Einar Key, to whom the credit of establishing the operation is mainly due, satisfactory results can be obtained if the operation is performed within ten hours in 75 per cent. of cases of axillary or brachial emboli, in 50 per cent. of femoral; in 30 per cent. of iliac; and in 15 per cent of emboli at the bifurcation of the aorta.

Technique.—The operation is usually performed under local anaesthesia. General anaesthesia is often contra-indicated by the poor general condition of the patient. The artery is freely exposed above and below the level of the embolus and is freed from the

surrounding structures together with any branches arising in the area exposed. Gentle and careful handling of the artery is essential lest the embolus be dislodged The segment occupied by the embolus is slightly distended and feels firmer than the normal vessel. The exact level of the embolus is determined by noting the limit of expansile pulsation A sensation of transmitted pulsation in the form of a longitudinal thrust is frequently felt in the occluded area. The artery distal to the embolus is contracted and compressible unless its lumen is filled by thrombus The surface of the wound is covered with gauze wrung out of 3·8 per cent. sodium citrate solution, and a similar pad is placed deep to the artery. An arterial clamp is applied to the artery above the embolus, using the minimum of pressure necessary to occlude the vessel, and similar clamps are placed to control the artery on the distal side of the embolus, and any large branch arising from this segment of the artery. An incision of 1–2 cm (½–1 in) in length is now made in the long axis of the artery immediately above the embolus. If, however, owing to the relations of the vessel there is insufficient room to make the incision between the embolus and the proximal clamp, the incision is placed distal to the embolus rather than directly over it. The embolus is removed, together with any thrombus attached to it, by gentle pressure from below upwards or by means of forceps. If the main vessel distal to the incision has been cleared of clot there will be a steady return flow of blood from the collateral circulation. When the patency of the peripheral vessels has thus been established, the clamps previously placed in position are gently closed and the proximal clamp is released for a few moments until it is obvious by the strong flow of blood in arterial jets that the central end of the vessel is clear of thrombi. Small secondary thrombi which may have formed above the embolus are swept out by the force of the restored blood-stream. Blood loss is limited by controlling the artery between finger and thumb until the clamp is reapplied The isolated segment of the artery is washed out with citrate solution or heparin and the wound in its wall is repaired as in the operation of lateral suture (p 8).

When there has been extensive thrombosis, it may be difficult to clear the artery below the level of the incision. Absence of a flow of blood from the peripheral end of the vessel indicates that the lumen is still occluded either by thrombus or by an earlier embolus in a more distal part of the artery If gentle stroking from below upwards fails to clear the artery it should be opened at a lower level It may then be possible to remove the remaining clots by the passage of a fine well-lubricated rubber catheter, or by the injection of citrate solution from the distal to the proximal opening.

When direct exposure of the artery is difficult and likely to place too great a strain upon the patient, it is advisable to open the artery in a more accessible position on the distal side of the embolus. If the clot is recent and not firmly attached, it can be separated by the passage up the lumen of the artery of a fine rubber catheter to which suction is applied, and is removed at once by the force of the arterial stream. An embolus of the *subclavian artery* can be removed in this way through an incision made in the third part of the *axillary artery*, while in the case of the *common iliac artery* the approach would be through an incision in the common femoral artery. The distal route is also preferred, and has been successfully employed, for the removal of an embolus at the bifurcation of the aorta. Both common femoral arteries should be exposed and lightly clamped. The embolus is freed by retrograde catheterization through an incision in one of the two vessels. The detached portions of the embolus are removed by the flow of blood when the patency of the artery has been restored. If this part of the operation has been successful, a clamp is applied proximal to the incision, which is then sutured. The clamp placed on the opposite femoral artery will arrest any fragments of clot which tend to travel distally on that side. An incision is therefore made in this artery also, all traces of clot are removed, and the incision is sutured.

Pulmonary Embolism.—Massive embolism of the pulmonary artery is so rapidly fatal that operation has to be carried out very quickly for success to be achieved On the first sign of thrombophlebitis following operation, heparin should be given intravenously in a dose of 150 mg. If the thrombophlebitis is not recognized and non-fatal pulmonary embolism occurs, heparinization will prevent the increase of the clot and cause rapid improvement in the pulmonary signs and symptoms. The administration of heparin has replaced pulmonary embolectomy in cases of massive embolism arising suddenly without previous recognition of a thrombophlebitis

Operations for Aneurysm

The gradually diminishing incidence of pathological aneurysm has rendered many of the classic operations obsolete. The methods of ligating the parent vessel well above the aneurysm (John Hunter), or beyond it (Brasdor, Wardrop), various measures designed to promote coagulation within the sac, and the complete extirpation of the sac, have been almost entirely superseded

The operations here described for traumatic aneurysm can be employed, with any necessary modifications for the corresponding pathological varieties.

Traumatic Arterial Aneurysm may result from gunshot or stab wounds, often after an arterial haematoma (p. 10). It is treated by double *ligation* of the supplying arterial trunk.

The *intrasaccular method* of ligation was practised by Syme (1861) and Annandale (1885) The circulation is controlled, the sac opened, the clot turned out, and a bougie passed into each end of the parent trunk. Through small incisions made through the wall of the sac at the proximal and distal orifices, ligatures are passed round the artery and tightened as the bougies are withdrawn.

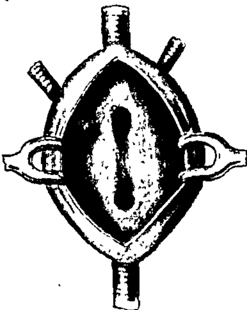
Arteriovenous Aneurysm arises when an artery and its companion vein are simultaneously injured, and a fistulous opening is formed between them, with or without an intervening sac.

The operation consists in exposing the site of communication, separating the artery from the vein, closing the aperture in the vein by a fine continuous silk suture carried through all coats, and that in the artery by lateral arteriorrhaphy (p. 18). If it is impossible to obliterate the opening and so to restore the lumen of the vessels, both artery and vein should be divided between ligatures above and below the point of communication (quadruple ligation).

Arteriovenous Haemangioma (Aneurysmal Varix) results from an anomalous development of vessels whereby blood passes directly from a dilated artery into even more dilated veins. It is most commonly met with on the surface of the brain and calls for special treatment

Aneurysmorrhaphy.—This technique was evolved by Matas, who described three types of operation designed respectively (*a*) to obliterate the sac, (*b*) to restore the arterial lumen and also to obliterate the sac, and (*c*) to reconstruct the artery by using part of the wall of the sac and obliterating the remainder In each of these operations the circulation is controlled, the sac is exposed and freely opened so that the whole of its interior may be examined when the clot and blood have been removed If the case is suitable for the *obliterative* operation, as in a fusiform aneurysm with thin walls weakened by atheromatous degeneration, the orifices of the parent vessel and of any branches which open into the sac are occluded by silk sutures The deeper part of the sac is then folded over the closed orifices by a series of Lembert sutures which bring the surfaces into apposition In the *restorative* operation the margins of the communication with the parent vessel are raised and brought together with a continuous suture, care being taken not to encroach on the lumen of the artery The sac is then obliterated by infolding and suture.

If on inspecting the interior of a fusiform aneurysm a distinct groove can be traced between the orifices of the parent vessel, and the



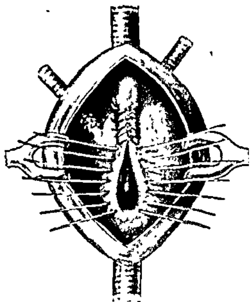
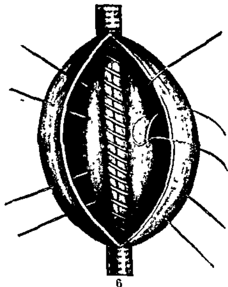


Fig. 5. Obliterative Endo-aneurysmorrhaphy, showing Closure of Communication between the Sac and the Artery, and of a Branch leaving the Sac (After Matas.)



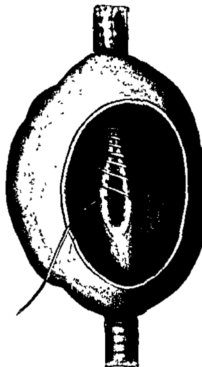


Fig 6 Obliterative Endo-aneurysmorrhaphy Communication with parent Vessel closed with Continuous Suture, and sutures introduced to obliterate the wall of the Sac. (After Matas)

Fig 7 Restorative Endo-aneurysmorrhaphy Orifice between Artery and Sac closed by Continuous Suture. (After Matas)

wall of the sac is strong and pliable, the *reconstructive* operation may be carried out. A piece of rubber tube lubricated with sterile liquid paraffin is placed in the groove and passed for a short distance into the proximal and distal ends of the vessel. Over this the walls of the sac are folded, and united by interrupted sutures which are tied proximally and distally, the tube is then withdrawn and the intervening sutures tied. A second row of sutures is inserted and the remainder of the sac is infolded and obliterated. These operations

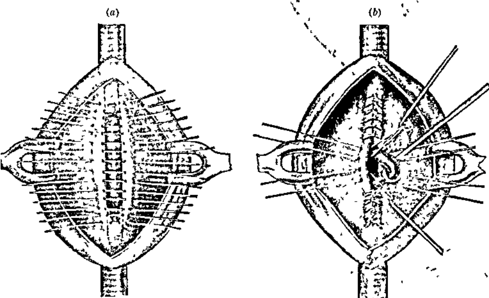


FIG. 8. Reconstructive Endo-aneurysmorrhaphy.
(a) Sutures inserted over rubber tube, (b) Tubes being withdrawn as sutures are tightened (After Matas)

have been employed in the treatment of both pathological and traumatic aneurysms with success, but thrombosis may occur at the site of suture unless intima is accurately apposed to intima; *any leakage at the suture line is likely to lead to recurrence of the* aneurysm.

TRANSFUSION OF BLOOD

The Prevention of Clotting.—Prevention of clotting is essential in blood transfusion, in the collection of specimens for various chemical investigations, in the surgical repair of injured arteries, and in the treatment of thrombosis and embolism. In shed blood coagulation may be prevented (1) by removing free calcium ions, e g. by the addition of potassium oxalate which forms insoluble calcium oxalate, or by the addition of sodium citrate which binds the calcium as a calco-citrate so that it is no longer ionized, (2) by

placing it in a container the surface of which is not wetted by water, e g. paraffin-treated tubes; (3) by the addition of heparin; and (4) by defibrination, fibrin being removed as quickly as it is formed by switching the blood with a fork.

Transfusion of Blood.—Human blood corpuscles contain agglutinogens of two types referred to as A and B, while blood-plasma contains agglutinins which are referred to as anti-A and anti-B. The blood of any individual cannot contain an agglutinogen and the corresponding agglutinin, or agglutination would occur. If an agglutinogen is absent from the corpuscles, the corresponding agglutinin is present in the serum so that four blood groups occur as shown in the following table:

Serum agglutinins	*Red cell agglutinogens*	*Group*	
		International	*Moss*
None	A and B	AB	1
Anti-B	A	A	2
Anti-A	B	B	3
Anti-A and B	None	O	4

For the purposes of transfusion it is sufficient to make certain that the donor's corpuscles are not agglutinated by the serum of the recipient. Even although the donor's serum contains agglutinins capable of acting on the patient's corpuscles agglutination does not occur, possibly because of the dilution of the donor's blood. It will be seen from reference to the table above that:

A recipient of Group AB may receive blood from Groups A, B, O, and AB
„ „ A „ „ A and O
„ „ B „ „ B and O
„ „ O „ „ O

Group AB is therefore often referred to as the universal recipient and Group O as the universal donor.

While it is justifiable in real emergency to give blood of Group O, in all other cases compatibility should be established by means of the direct test, the donor's corpuscles being matched with the serum of the recipient. The demands on blood transfusion services for Group O blood are great; the blood group of the recipient should be determined and blood of the same group transfused whenever possible

Determination of the Patient's Blood Group.—A suspension of the patient's corpuscles in sodium citrate or saline solution is made by adding one drop of blood to 1 c.c. of normal saline or 3 per cent. sodium citrate in a small tube. One drop of this suspension is mixed with serum of Group A on a carefully labelled glass slide, and

a similar slide is prepared with serum of Group B. The preparations are covered with cover slips and are examined under the microscope. If agglutination occurs, it is apparent usually within a few minutes. The following table shows how the group of the corpuscles is determined

Agglutination with serum of		*Group to which corpuscles belong*
Group A	*Group B*	
Yes	Yes	AB
No	Yes	A
Yes	No	B
No	No	O

Direct Test.—The recipient's serum is mixed with a suspension of the donor's corpuscles as described in group testing above Absence of agglutination shows that the donor's blood is compatible with that of the patient.

Methods of Transfusion.—The standard method of transfusion is to use blood which has been rendered non-coagulable by the addition of sodium citrate There is no risk of any toxic reaction with the amount of sodium citrate which is required, the coagulation time of the recipient's blood is not affected, and the sodium citrate is rapidly excreted Citrated blood has the great advantage that it is suitable for storing in a blood bank.

The Taking of Blood from the Donor.—Sodium citrate will prevent coagulation when mixed with blood in a proportion of 0·2 per cent., but in practice it is advisable to use an isotonic (3·8 per cent.) solution of sodium citrate, 50 c.c. of the solution are used for every 450 c.c. of blood so that the blood citrate mixture contains 0·38 per cent. sodium citrate.

The donor lies on a couch, and a tourniquet or sphygmomanometer cuff is applied to one upper arm with sufficient tension to obstruct the venous return from the arm The skin over the front of the elbow is prepared and a suitable prominent vein is selected The apparatus is sterilized and assembled in readiness; it consists of a bottle which contains 50 c.c. of 3·8 per cent. citrate solution, the rubber cork of which is perforated to carry two tubes; one leads by rubber tubing to a suitable needle, the other provides an outlet for air. The needle is inserted into the vein and the blood is collected into the bottle which is placed on the floor by the side of the patient. When the desired amount of blood has been drawn off, the tourniquet is released and the needle is withdrawn from the vein. A few seconds' pressure with a swab is sufficient to stop any oozing from the venepuncture and a small dressing is then applied The cork is with-

drawn from the bottle, which is sealed by a well-fitting screw cap; a few drops of the citrated blood are placed in a small tube which is attached to the bottle to be available for direct testing when the blood is to be used. The group and the date of bleeding are clearly marked on the bottle, which is stored in the refrigerator if it is not required immediately.

Methods of giving Blood to the Patient.—Except in grave emergency a direct test is carried out. Bottles of compatible blood and a sterilized 'giving set' may be obtained from the blood bank. A tourniquet or sphygmomanometer cuff is applied to the arm of the patient to obstruct the venous return and the skin over a suitable vein is prepared. If the transfusion is to be given slowly by the drip method or if the amount to be given is large, the limb should be immobilized in a comfortable position on a splint, and it is preferable not to select a vein at the bend of the elbow because full supination is not a comfortable position to maintain for any length of time. A vein on the radial side of the forearm or at the ankle is preferable. The cap is removed from the bottle and replaced by the cork of the giving set, which carries two tubes, one of these is short and has an air filter incorporated in it, while the other is longer and leads through a drip feed to an adaptor which fits either the needle or cannula supplied. A screw clip on this tubing controls the rate of flow. In other types of apparatus the 'giving set' consists of two stout, sharp-pointed metal tubes, one long and the other short, which take the place of the perforated cork. These are passed through the rubber cork of the bottle through the openings on its upper surface. The bottle of blood is inverted twice to ensure mixing of its contents and hung inverted from a suitable stand attached to or close to the patient's bed. The tube and needle are cleared of air, the needle is inserted into the vein, and as soon as this has been verified by the escape of blood the tourniquet is removed, the adaptor is connected to the needle, and the transfusion is begun The needle is fixed in position by strapping, and the rate of transfusion adjusted by means of the clip.

If there are no suitable veins visible, a vein should be exposed by dissection under local anaesthesia An incision is made across or in the line of the chosen vein, it is cleared and two ligatures are passed round it, the distal one being tied. The vein is then opened with sharp-pointed scissors, and a cannula is inserted into the lumen and secured in position by tying the proximal ligature round it. As soon as the blood is running satisfactorily the wound is closed, the cannula being fixed by strapping or by a stitch

Administration of Blood to Infants and Children—Though accessible through the anterior fontanelle, the superior sagittal sinus

should not be used because of the dangers of leakage if the needle is not wholly in its lumen The long saphenous vein in front of the medial malleolus is constant in position and even in infants is usually large enough to accommodate a small cannula. If a vein cannot be found, blood may be given into the marrow of the tibia by means of a special needle.

Reactions to Transfusion.—Severe reactions due to the giving of incompatible blood occur after quite a small amount of blood has been transfused There are rigors, pain in the back, vomiting, and respiratory distress. The transfusion is stopped as soon as symptoms occur The results of the agglutination of the donor's corpuscles are indicated by the development later of jaundice and haemoglobinuria. Renal failure may follow, possibly owing to the blocking of the renal tubules with haematin Haematin is precipitated in acid solutions, so that on the slightest suggestion of incompatible transfusion alkalies should be given and the fluid intake increased The urine should be kept alkaline as long as pigment is being excreted.

Mild reactions should be treated by slowing down the transfusion, a close watch being kept on the patient for further reactions.

Possible Dangers of Multiple or Repeated Transfusions.—Despite most careful matching, severe reactions and even fatalities have followed apparently compatible transfusion In most cases these reactions are due to the presence of an anti-Rh factor. In addition to their ABO agglutinogens, about 85 per cent of human red cells contain an agglutinogen similar to that found in the red corpuscles of Rhesus monkeys In the minority this agglutinogen is absent. If such Rh-negative individuals are transfused with the blood of a Rh-positive donor, or if Rh-negative women become pregnant with a foetus whose red corpuscles contain the Rh factor, they will develop anti-Rh agglutinins in their serum. Such an anti-Rh agglutinin is never found under other circumstances, but should a subsequent transfusion be carried out with Rh-positive blood, severe or even fatal reactions may follow. For such cases blood banks have available Rh-negative blood.

Plasma, Serum, and Red Cell Suspension Transfusions.—Fluid plasma is obtained from over-age blood in the blood bank by removing the supernatant fluid from the citrated blood The blood of different groups is mixed and time is allowed for the absorption of agglutinins by the corpuscles so that the plasma becomes agglutinin-free. As plasma contains fibrinogen, clotting may occur in it, but provided that the fluid is clear it is fit for use; turbidity indicates that the plasma is infected.

Fluid serum is obtained from blood which has been allowed to clot. It has a higher protein content than plasma and does not

contain fibrinogen. The agglutinin content is reduced by pooling the sera, but reactions are more likely than with plasma.

Dried plasma and serum are obtainable and are reconstituted by the addition of sterile distilled water or glucose-saline.

Plasma or serum is indicated to replace the plasma loss following extensive burns and in hypoproteinaemia, and may be employed to restore the blood volume in traumatic shock not associated with haemorrhage. Plasma and serum do not cause reactions due to the Rh factor.

In the treatment of anaemia suspensions of washed red corpuscles may be used. Red cells are obtained as a by-product in the preparation of plasma. Red cell suspensions have the advantage of augmenting the oxygen-carrying capacity of the blood without the necessity for large transfusions.

Normal Saline, Glucose-Saline, &c.—Crystalloid solutions are indicated in the treatment of dehydration, but are of little value in the treatment of shock because they are retained in the circulation only for a very short period

All these substances are given intravenously in the same way as blood.

Operations on Veins

Operations for Varicose Veins.—Varicose veins are usually treated by a combination of operation and injection of sclerosing agents. Injection alone is useless if the valves of the long saphenous vein are incompetent, or if the communicating veins between the long saphenous and femoral vein are incompetent In these circumstances the long saphenous vein must be dealt with at its junction with the femoral vein, and it may be necessary to divide it between ligatures at other levels.

To determine the extent of operation required, a tourniquet which obstructs only the superficial venous return is placed on the limb, when the veins are empty. first, immediately distal to the saphenous opening; if the veins do not refill in the erect position, only the upper saphenous valves are incompetent; if the veins refill, the band is placed, second, at mid-thigh, and third, immediately above the knee. A level may be found at which the tourniquet prevents refilling: if refilling still occurs, then the short saphenous vein must be tied at its junction with the popliteal vein.

Ligation at the Saphenous Opening.—Local or light general anaesthesia may be used. An incision 7·5 cm. (3 in.) long is made parallel to the inguinal ligament, its mid-point 4 cm. (1½ in.) distal and 4 cm. (1½ in.) lateral to the pubic spine. The saphenous vein is isolated to its junction with the femoral, and every tributary joining it is

divided between ligatures—an essential step which requires adequate exposure The vein is then ligated at its junction with the femoral, and again 2 cm (¾ in) distally, the distal ligature being a transfixion one The vein is opened beyond the distal ligature, and a No. 5

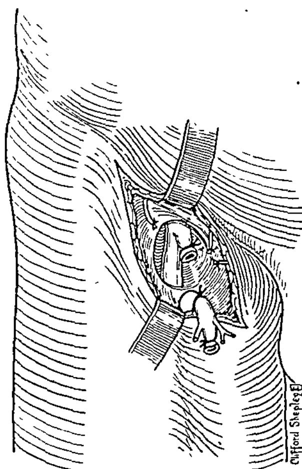


FIG. 9 Ligation of Internal Saphenous Vein and its Branches at the Saphenous opening

ureteral catheter passed distally as far as it can be manœuvred; as the catheter is withdrawn, from 2 to 4 c c. of ethamolin are injected. The vein is then ligated below the opening for the catheter, and the segment (2·5 to 5 cm.; 1 to 2 in) between the middle and distal ligature is excised The wound is closed in such a way as to obliterate dead space, and dressed with elastoplast to prevent contamination from the groin or perineum. The patient is ambulant from the first.

Ligation in the Thigh.—If the tests have shown the need to ligate

the long saphenous vein in the thigh, its course should be mapped out before operation with an indelible dye (brilliant green answers well). It may be possible, through the more distal incision, to reach the veins in the leg with sclerosing solution; not more than 5 c.c. in all should be introduced at one sitting.

Ligation of the Short Saphenous Vein.—A short longitudinal incision is made over the termination of the vein, which is marked previously with dye. The vein is ligated flush with the popliteal vein and divided between ligatures.

Injection of Varicose Veins.—When the valves in the long saphenous vein are competent, distal varices may be obliterated by injecting a sclerosing solution into a dilated segment, and repeating the injection at intervals of five to seven days, until all the varicosities have been treated. The sclerosing agent which we employ is the proprietary preparation ethamolin.

Distal veins are injected first so that their prominence is not obscured by more proximal thrombosis. The patient should be recumbent, and if necessary the selected vein may be made prominent by the application of a sphygmomanometer cuff above the knee, at a pressure of about 60 mm. mercury. The skin is carefully sterilized. A syringe with an eccentric nozzle is a convenience, and the needle (size 18 or 20) should have a short bevel. The vein is entered in a proximal direction and the position of the point of the needle is verified by the withdrawal of blood, after which the needle must not be moved. The tourniquet is released, the vein emptied, and from 2 to 4 c.c. of solution slowly injected. The needle is withdrawn and the puncture is compressed with a small pledget for a minute or two, after which the pledget is retained in position by adhesive plaster. The patient may walk at once.

When varices in the short saphenous system are being injected, the needle should be directed distally, to avoid passage of the sclerosing solution into the popliteal vein.

Extreme care must be taken to prevent the injection reaching the perivenous tissues.

OPERATIONS ON INDIVIDUAL ARTERIES

In most cases the entire course of the artery is included in the operative approach, but part of this may be employed, e.g. for the exposure of the femoral or brachial arteries for arteriography.

The Innominate Artery

This artery arises from the convexity of the arch of the aorta behind the centre of the manubrium sterni and passes upwards and

to the right to the upper part of the right sternoclavicular joint, behind which it divides into the right subclavian and common carotid arteries.

In front of the artery are the left innominate vein, sternothyroid and sternohyoid muscles, the manubrium sterni and the sternoclavicular joint. On its left side, below, lies the left common carotid artery and at a higher level the trachea. On its right side, below, lies the superior vena cava while at a higher level are the right innominate vein, the right vagus, and the pleura.

Exposure of the innominate artery is indicated in aneurysm of the first or second parts of the subclavian artery or of the lower part of the common carotid artery, as well as in aneurysm of the artery itself It is necessary to bring into view the origins of the common carotid and subclavian arteries to establish the site of a lesion low down in the root of the neck

Technique.—The patient is placed in the supine position with the head turned to the opposite side, and the shoulder on the affected side is strongly depressed. Sandbags are placed behind the affected side to allow the shoulder to fall backwards when the clavicle has been divided. (Figs. 10, 11.)

The incision begins at the medial border of the trapezius muscle 3·5 cm. (1½ in.) above the clavicle and runs medially to the middle line above the suprasternal notch, whence it curves downwards in the median line of the sternum to end below the manubrium sterni. The reflection of this flap exposes the manubrium, the sternoclavicular joint, the sternomastoid, and the clavicle. The periosteum is separated from the clavicle immediately lateral to the sternomastoid, and two small holes about 2·5 cm. (1 in.) apart are drilled through it During this step the underlying pleura and subclavian vein are protected by passing a malleable retractor round the bone, which is then divided between the drill holes with a Gigli saw The sternomastoid is separated by a dissector from the structures deep to it and is then divided in the line of the skin incision. The finger now clears the deep surface of the manubrium so that it may be safely split in the middle line. This is most easily done by making a burr hole through the manubrium at the level of the upper border of the second costal cartilage and passing a guide through it to the suprasternal notch, which threads a Gigli saw posterior to the manubrium The division of the manubrium is completed by a cut which passes laterally from the lower end of the previous cut to the lateral border of the bone at the upper border of the second costal cartilage. The osteoplastic flap is completed by clearing the deep surface of the first costal cartilage and dividing it The flap is elevated and turned laterally on its attachment to the pectoralis major muscle.

The pleura is cleared laterally by gentle gauze dissection and the contents of the superior mediastinum are displayed. The left *innominate* vein is identified and is carefully freed and retracted

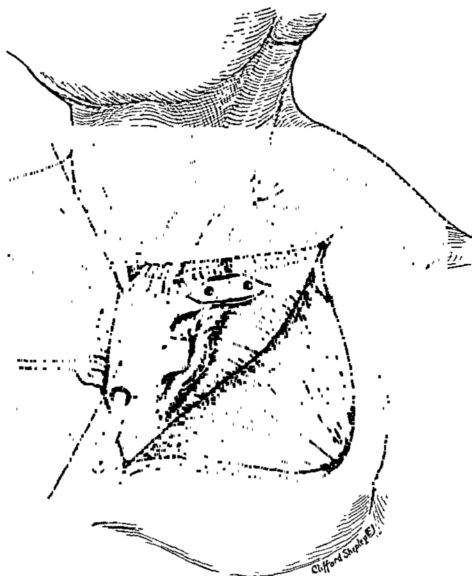


FIG. 10. Exposure of Left Common Carotid or of Innominate Artery: Stage I.

downwards and laterally. The thyroidea ima artery may arise from the anterior aspect of the innominate artery and the inferior thyroid vein is also anterior to it. These vessels may be secured and divided.

The wound is closed by replacing the osteoplastic flap, wiring the clavicle, and suturing the sternomastoid muscle. If drainage is

required, the drain is placed in the lateral angle of the incision. A bandage is applied over massive dressings so that the head is firmly fixed with the sternomastoid fully relaxed.

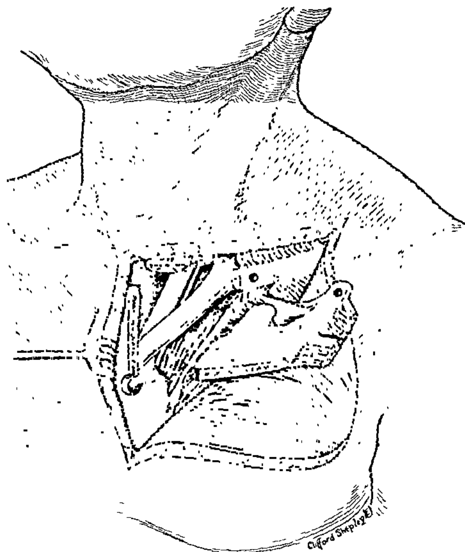


FIG 11. Exposure of Left Common Carotid or of Innominate Artery Stage 2.

The collateral circulation, following ligation of the innominate artery, depends on the carotid and vertebral arteries of the opposite side. The two internal carotid and vertebral arteries communicate through the circulus arteriosus and the branches of the extenal carotid arteries anastomose across the median plane both in the neck and face. The collateral circulation to the arm is established through

the intercostal anastomosis. Cerebral complications appear to be less likely than after occlusion of the common carotid artery, and the collateral circulation to the upper limb is sufficient.

On the left side a similar approach is used to display the *intrathoracic portions of the left subclavian and left common carotid arteries.* The left common carotid artery has the left innominate vein in front of it; at first the subclavian artery lies posterior, more peripherally to its left side. The vagus nerve lies in the groove between the two arteries and is crossed superficially from left to right by the phrenic nerve.

The Carotid Arteries

The common carotid artery runs upwards and slightly laterally from behind the sternoclavicular joint to the level of the upper border of the thyroid cartilage. Its course is indicated by a line drawn from the upper border of the sternoclavicular joint to a point midway between the tip of the mastoid process and the angle of the mandible. The portion of this line below the level of the upper border of the thyroid cartilage corresponds to the common carotid artery: at this level the artery bifurcates into the internal and external carotid arteries, the upper portion of the line corresponding to the external carotid.

Technique.—The common carotid, external carotid, and proximal part of the internal carotid arteries can be exposed by an incision along the anterior border of the sternomastoid. This approach must be extended if it is desired to expose the distal part of the internal carotid in the neck or the proximal portion of the common carotid.

The patient lies supine with a sandbag or small pillow under the shoulders. The head is hyperextended and turned to the opposite side. The incision is made along the anterior border of the sternomastoid muscle. The superficial fascia, platysma, and deep fascia are divided, and the anterior border of the muscle is defined and retracted laterally, to expose, from below upwards, the sternohyoid and sternothyroid muscles with the anterior jugular vein crossing them, the middle thyroid vein crossing the carotid sheath; the ansa hypoglossi on the front of the carotid sheath; the lateral lobe of the thyroid gland which overlaps it from the medial side; the omohyoid, which crosses the carotid sheath, and at a higher level the sternomastoid artery, superior thyroid vein, and descendens hypoglossi nerve lying superficial to the carotid sheath. On the left side the internal jugular vein overlaps the lower part of the artery. The internal jugular vein lies lateral to the artery, while the vagus nerve is postero-lateral to it Posterior to the common carotid are the sympathetic trunk, the vertebral and inferior thyroid arteries, and

from the artery, leaving a gap in which the vagus nerve lies. On the left side the artery may be followed into the inlet of the thorax where the manubrium sterni, the sternohyoid and sternothyroid muscles, the thymus and the left innominate vein lie in front of it. Lateral to it lie the pleura, vagus and phrenic nerves, and posterior the subclavian artery and recurrent laryngeal nerve.

Subclavian and Axillary Arteries

Third Part of the Subclavian Artery.—Below lie the first rib and pleura, behind are the lowest trunk of the brachial plexus or the first thoracic nerve and the scalenus medius muscle, while above run the middle and upper trunks of the brachial plexus.

First Part of Axillary Artery.—In front the clavi-pectoral fascia is pierced by the cephalic vein, lateral pectoral nerve, and acromiothoracic artery. Supero-lateral are the lateral and posterior cords of the brachial plexus and the lateral pectoral nerve. Posteriorly the artery is separated from the first intercostal space by the medial cord of the brachial plexus, the medial pectoral nerve, and the nerve to the serratus anterior, while infero-medial lies the axillary vein.

Second Part of the Axillary Artery—Posteriorly is the posterior cord of the brachial plexus, laterally the lateral cord of the plexus, while on the medial side the medial cord of the plexus intervenes between the artery and the vein.

Third Part of the Axillary Artery—Anteriorly the lateral vena comitans crosses the artery to join the medial vein while the medial root of the median nerve, the medial cutaneous nerve of the forearm, and the overlapping axillary vein lie in front. On the lateral side the median and musculo-cutaneous nerves lie between it and the axillary vein. The circumflex and radial nerves lie posterior to the artery.

Technique.—The patient lies supine with a sand pillow between the scapulae. The shoulder on the affected side overlaps the operating table and is abducted to a right angle by an assistant. The head is extended and rotated to the opposite side. The exposure is a combined supraclavicular and axillary approach, access being secured by two incisions: (*a*) from the junction of the middle and outer thirds of the sternomastoid muscle 2·5 cm. (1 in.) above the clavicle, to a point 5 cm. (2 in.) lateral to the anterior border of the trapezius, and (*b*) from the supraclavicular incision at the outer border of the sternomastoid obliquely downwards and laterally to cross the anterior fold of the axilla close to its junction with the upper arm (Figs. 14–15.)

The dissection is begun in the axillary portion of the incision. The fasciae are divided and the pectoralis major muscle exposed and divided in the line of the incision, when there may be considerable

bleeding from the muscular branches of the acromio-thoracic artery. These bleeding-points should be secured individually and the main trunk of the vessel spared—it is seen piercing the clavi-pectoral fascia

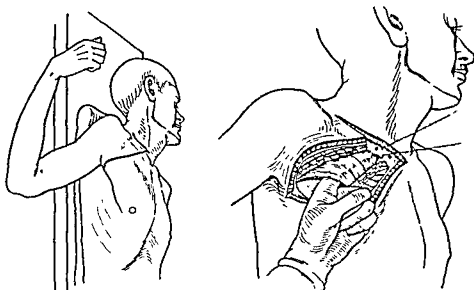


FIG. 14. Exposure of Subclavian and Axillary Arteries showing Position of Patient and Line of Incision, and Method of dividing Clavicle and Pectoralis-major Muscle

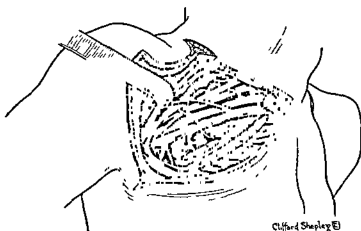


FIG. 15. Exposure of Subclavian and Axillary Arteries: Dissection completed

above the pectoralis minor muscle. The pectoralis minor muscle is divided close to its insertion and the clavicle is then exposed and cleared. With the deeper tissues separated and protected by the passage of a malleable metal retractor round the bone it is drilled in two places and divided between the drill holes by a Gigli saw. The

underlying subclavius muscle is then divided and the axilla is opened up widely by lateral rotation of the arm. The vessels and nerves are enclosed in a sheath which must be incised in order to display them.

The supraclavicular incision is now deepened. The superficial fascia, the platysma, and the deep fascia are divided, and the anastomoses of the external jugular with the transverse cervical and suprascapular veins are exposed and divided between ligatures. The second layer of deep fascia attached to the deep surface of the clavicle is divided, when the nerve to the subclavius may be seen, and a third fascial layer continuous with that on the scalenus anterior must be divided to expose the third part of the subclavian artery which lies in the triangle formed by the clavicle, the omohyoid, and the lateral edge of the scalenus anterior. The subclavian vein is anterior to the artery and at a lower level.

In some cases it may be necessary to expose the *second* and even the *first parts of the subclavian artery* This is accomplished by extending the supraclavicular incision medially across the sterno-mastoid muscle which is carefully divided on a dissector; the medial fragment of the clavicle can then be retracted downwards. The suprascapular and transverse cervical arteries are identified between the sternomastoid and the scalenus anterior muscles, and the phrenic nerve is separated from the surface of the latter muscle and retracted medially The scalenus anterior is then divided close to its attachment to the first rib. The internal jugular and subclavian veins at their junction to form the innominate vein are then gently displaced medially, and the subclavian artery is completely exposed

In closing the wound the shoulder is rotated medially, the clavicle is wired, and the pectoral and sternomastoid muscles are sutured. Drainage is best provided through a stab wound in the axilla. The elbow is supported against the side and the forearm is placed across the chest with the hand pointing to the shoulder of the sound side and secured by plaster bandages which are retained for three weeks, thereafter graduated movements are begun

The Brachial Artery

The brachial artery begins at the lower border of the teres major muscle and ends in the cubital fossa antero-medial to the neck of the radius by dividing into the radial and ulnar arteries Its line is from the junction of the middle and outer thirds of the axilla to a point a finger's breadth below the bend of the elbow.

Technique.—The patient lies in the supine position, the arm being abducted, externally rotated at the shoulder, and slightly flexed at

the elbow. If this position is maintained by placing the arm on a table, the triceps muscle is pressed forwards and so displaces the structures as to make it possible to mistake the ulnar nerve and ulnar collateral artery for the median nerve and brachial artery. The limb is therefore held at the elbow by an assistant or the forearm may be supported on a table. (Fig. 16.)

The incision is made in the line of the artery, along the medial border of the biceps muscle. In the lower part of the wound the basilic vein lies superficial to the deep fascia, just medial to the line of the incision, but in the upper part of the exposure it lies deep to the deep fascia on the medial side of the artery. The deep fascia is divided and the coraco-brachialis and biceps muscles are identified, freed, and retracted laterally. The neurovascular bundle is thus displayed.

The relationships of the structures are: above the insertion of the coraco-brachialis muscle the ulnar nerve and the medial cutaneous nerve of the forearm lie on the medial side of the artery, but at this level the ulnar nerve passes medially with the ulnar collateral branch of the artery to pierce the medial intermuscular septum, and the medial cutaneous nerve of the forearm pierces the deep fascia to pass superficially with the basilic vein. Close to the origin of the artery the medial cutaneous nerve of the forearm lies anterior to it. The median nerve lies lateral to the brachial artery above the middle of the arm where it crosses the artery superficially to lie on its medial side. A short distance from its origin the brachial artery gives off the profunda artery. The radial nerve lies posterior to the first 2·5 cm. (1 in.) of the brachial artery, but leaves it along with the profunda vessels by passing between the long and the medial heads of the triceps muscle. In the lowest part of the incision in the cubital fossa the artery lies deep to the bicipital aponeurosis with the median nerve on its medial side; superficial to this it is crossed by the median cubital vein.

The upper part of the approach is also used to expose the third part of the axillary artery.

After retracting the coraco-brachialis muscle to the lateral side the median nerve is seen lateral to the artery, with the musculo-cutaneous nerve between it and the coraco-brachialis muscle. The ulnar nerve, axillary vein, and medial cutaneous nerve of the arm lie to its medial side in that order. In front of the artery lie the medial root of the median nerve and the medial cutaneous nerve of the forearm Behind it lie the radial and circumflex nerves, but the circumflex nerve soon leaves it to pass posteriorly through the quadrilateral space.

The profunda artery of the arm can be exposed by retracting the

underlying subclavius muscle is then divided and the axilla is opened up widely by lateral rotation of the arm. The vessels and nerves are enclosed in a sheath which must be incised in order to display them

The supraclavicular incision is now deepened. The superficial fascia, the platysma, and the deep fascia are divided, and the anastomoses of the external jugular with the transverse cervical and suprascapular veins are exposed and divided between ligatures. The second layer of deep fascia attached to the deep surface of the clavicle is divided, when the nerve to the subclavius may be seen, and a third fascial layer continuous with that on the scalenus anterior must be divided to expose the third part of the subclavian artery which lies in the triangle formed by the clavicle, the omohyoid, and the lateral edge of the scalenus anterior The subclavian vein is anterior to the artery and at a lower level.

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Technique.—The patient lies in the supine position, the arm being abducted, externally rotated at the shoulder, and slightly flexed at

the radius. The radial artery passes deep to the brachio-radialis and the ulnar deep to the pronator teres. Retraction of the brachio-radialis allows exposure of the radial artery. Retraction of the pronator teres is facilitated by pronating the forearm. The ulnar artery is identified; almost at its origin it gives off the anterior and posterior ulnar recurrent arteries, and about 2·5 cm. (1 in.) below its origin the common interosseous artery, which divides into anterior

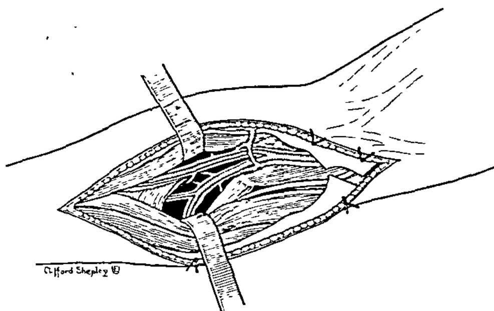


Fig. 17. Exposure of Distal Part of Brachial Artery and Proximal Segments of Radial and Ulnar Arteries.

and posterior branches. The upper part of the anterior interosseous artery can be seen in the lower part of the incision

The wound is closed by suture of the skin.

Ulnar and Radial Arteries

The Ulnar Artery in the Lower Two-thirds of the Forearm.—The course corresponds to the lower two-thirds of a line from the medial epicondyle of the humerus to the radial side of the pisiform bone.

The patient lies supine with the arm abducted at the shoulder and extended at the elbow. The forearm is supinated. The incision is made in the line of the artery and the deep fascia is opened in the same line. The dissection is continued by mobilizing and retracting the flexor carpi ulnaris muscle, in the upper part of the wound the flexor carpi ulnaris is adherent to the septum between it and the flexor digitorum sublimis muscle, and unless the tendon of the former is traced upwards the line of cleavage is difficult to determine.

basilic vein, brachial artery, and median nerve to the medial side, when the radial nerve and the profunda artery are seen.

Anatomical variations are common in the brachial artery and in its relationships to other structures. Some of the more important are: (*a*) the artery may divide into its terminal branches at any level in the arm, and (*b*) the median nerve may cross from lateral to medial side behind the artery instead of in front of it.

Termination of the Brachial and Origin of the Forearm Arteries.— The patient lies supine with the arm abducted. The forearm is extended and supinated and may be supported on an arm rest or side

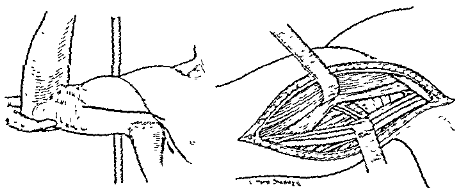


Fig 16. Exposure of Brachial Artery with its Profunda Branch.

table. The guides for the incision are the biceps tendon and the interval between the brachio-radialis and pronator teres muscles. The incision begins at least 2·5 cm. (1 in) above the elbow crease and runs downwards along the medial side of the biceps tendon, curving to the lateral side along the line between pronator teres and the brachio-radialis to end on the front of the radius at the junction of its middle and upper thirds (Fig 17.)

In the upper part of the incision the median cubital vein crosses the line of exposure and is divided between ligatures The medial cutaneous nerve of the forearm may cross deep or superficial to this vein; it is retracted to the medial side The deep fascia in the cubital fossa, the bicipital aponeurosis, and the deep fascia of the forearm are divided in the line of the incision. In the cubital fossa the median nerve is seen lying medial to the artery which is surrounded by venae comitantes. The median nerve is followed distally to the point where it leaves the fossa by passing between the heads of pronator teres; this muscle is retracted to the medial side, while brachio-radialis is retracted laterally The brachial artery courses lateral to the median nerve, between it and the biceps tendon The artery divides into the radial and ulnar arteries at the level of the neck of

the inferior mesenteric artery and the rectal branches of the internal iliac; the uterine, ovarian, and vesical arteries of the other side; and the internal mammary, intercostal, and lumbar arteries with the deep epigastric.

Internal Iliac Artery

The internal iliac artery is about 3·5 cm. (1½ in.) in length. It arises at the bifurcation of the common iliac on the medial border of

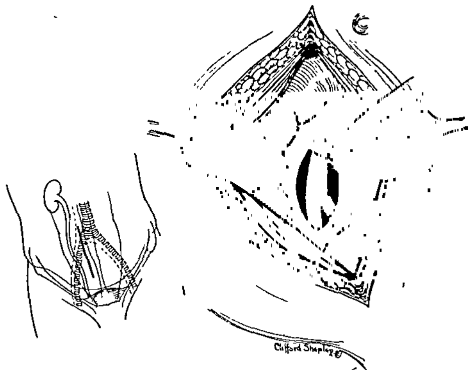


Fig 18. Transperitoneal Exposure of Right Common Iliac Artery. The Ureter is displaced medially.

the psoas muscle and dips downwards and backwards into the pelvis to end at the upper border of the greater sciatic notch by dividing into anterior and posterior divisions The ureter lies in close relationship to its inferior surface, while superior to it lie the internal iliac vein, the origin of the common iliac vein, and the lumbo-sacral trunk. In addition to branches supplying the pelvic viscera it gives off the superior and inferior gluteal, the obturator, and internal pudendal arteries. The artery may be exposed for the temporary control of bleeding at operation on a gluteal aneurysm, or because of uncontrollable secondary haemorrhage from a wound of the buttock.

The operative approach is similar to that employed for the common iliac artery.

The vessels and nerve lie in a fascial sheath which is attached to the surface of the deep flexor muscle. The sheath is opened and the artery found between its venae comitantes with the ulnar nerve on its medial side.

The Radial Artery in the Lower Two-thirds of the Forearm.—The course of the artery is indicated by a line drawn from the middle of the cubital fossa, opposite the level of the neck of the radius, to the front of the lower end of the radius

The patient lies supine with the arm abducted, the elbow extended, and the forearm supinated and supported on an arm rest or side table The incision is made in the line of the artery, and deep fascia divided in the same line. In the proximal part of the wound the brachio-radialis is identified and retracted laterally, in the lower part of the wound the artery is superficial.

Common Iliac Artery

The common iliac artery begins at the level of the line joining the highest points of the iliac crests, 2·5 cm. (1 in.) below and to the left of the umbilicus. A line drawn with a gentle lateral curve from this point to a point midway between the anterior superior spine of the ilium and the symphysis pubis indicates the course of the common and external iliac vessels, the upper third of the line corresponding to the common iliac and the lower two-thirds to the external iliac artery

The common iliac artery passes downwards and laterally across the bodies of the fourth and fifth lumbar vertebrae on the psoas muscle and terminates at the level of the lumbo-sacral joint anterior to the corresponding sacro-iliac joint, by dividing into the internal and external iliac arteries Near the bifurcation the ureter crosses anterior to the artery The nerves from the sympathetic trunk to the hypogastric plexus lie anterior to the artery, and on the left side the artery is also crossed anteriorly by the superior rectal artery. Behind the common iliac artery lies the sympathetic trunk, and behind the right common iliac artery the two common iliac veins join to form the inferior vena cava

Technique.—The artery is exposed by a median or paramedian trans-peritoneal incision The patient is placed in the Trendelenburg position and the intestines are displaced upwards and retained by gauze packs. The common iliac artery is readily identified by its pulsations, the posterior parietal peritoneum over it is incised and retracted, and the sheath of the artery opened. The artery is isolated, care being taken to avoid the ureter On the right side great care is taken to avoid injury to the iliac veins.

The collateral circulation depends on the anastomoses between

the inferior mesenteric artery and the rectal branches of the internal iliac; the uterine, ovarian, and vesical arteries of the other side; and the internal mammary, intercostal, and lumbar arteries with the deep epigastric.

Internal Iliac Artery

The internal iliac artery is about 3·5 cm. (1½ in.) in length. It arises at the bifurcation of the common iliac on the medial border of

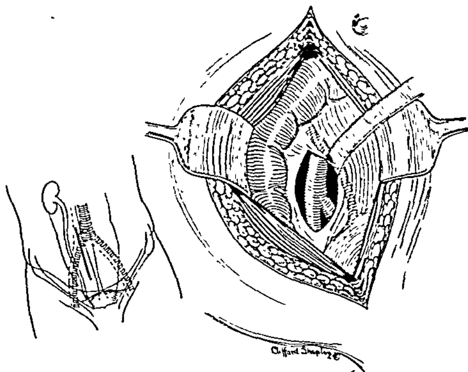


Fig. 18. Transperitoneal Exposure of Right Common Iliac Artery. The Ureter is displaced medially.

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The operative approach is similar to that employed for the common iliac artery.

Arteries of the Buttock

In haemorrhage from the buttock it may be difficult to identify the vessel involved. For this reason, and because of the proximity of other important structures, it is essential to secure adequate exposure of the area.

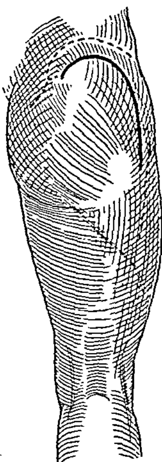


Fig. 19. Exposure of the Arteries of the Buttock Line of Incision

Technique.—The patient lies on the unaffected side with the sound leg flexed at hip and knee. The affected limb is so placed that the hip is extended and rotated laterally in order to relax the fibres of the gluteus maximus muscle.

The greater trochanter and the posterior superior iliac spine are identified. The incision begins below, over the middle of the greater trochanter, and passes proximally to a level 5 cm. (2 in.) distal to the iliac crest, where it turns backwards to run 5 cm. (2 in.) below and parallel to the iliac crest; it ends at the level of the posterior superior iliac spine. The superficial fatty tissues are divided to expose the upper end of the ilio-tibial tract in the lower part of the incision and in the upper part the fascia covering the gluteus maximus. The ilio-tibial tract is incised and a finger inserted deep to it elevates the gluteus maximus muscle from the deeper structures. The gluteus maximus muscle is divided in the line of the incision until the fascia overlying its origin is reached This portion of the muscle is divided parallel to the iliac crest, and it is then possible to retract the muscle posteriorly as a flap. Retraction of the muscle may be prevented by muscular branches of the superior gluteal artery which enter the deep surface of the muscle, these arteries are secured and divided. In the anterior portion of the wound lies the gluteus medius muscle. Coming from under cover of the posterior flap, and running downwards and laterally to join the lower part of the posterior border of the gluteus medius is the piriformis muscle, which is the key to all further dissection The definition of these muscles may require considerable separation of the abundant fatty tissue which is often

found superficial to them. Emerging from under cover of the lower border of the piriformis muscle, from lateral to medial side, are the sciatic nerve with the nerve to the quadratus femoris muscle hidden in front of it and the posterior cutaneous nerve of the thigh medial to or behind it; the inferior gluteal vessels and nerve; the nerve to the

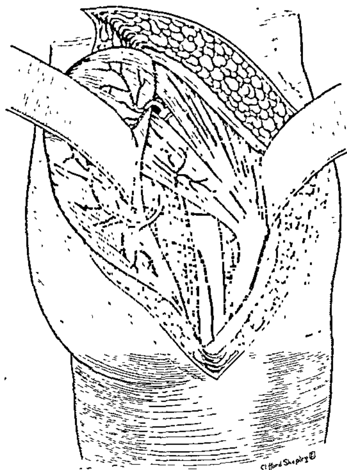


FIG. 20. Exposure of Arteries of the Buttock The gluteus maximus muscle has been reflected posteriorly to display the superior gluteal vessels above the piriformis muscle and the inferior gluteal vessels below that muscle.

obturator internus; and finally, the internal pudendal vessels and the pudendal nerve.

Emerging above the piriformis muscle are the superior gluteal vessels and nerve. Only the superficial division of the artery can be seen until the postero-medial border of the gluteus medius is retracted forwards, when the deep branch of the artery is found as it passes forwards between the gluteus medius and minimus If these branches are followed proximally into the upper part of the greater sciatic

notch a small part of the trunk of the superior gluteal artery is exposed.

To close the wound the gluteus maximus is replaced and sutured in position by interrupted stitches, which unite both muscle and aponeurosis. If drainage is required the drain is brought out above the greater trochanter.

External Iliac Artery

The external iliac artery arises at the level of the lumbo-sacral joint as a terminal branch of the common iliac artery. It runs downwards and laterally to the mid-inguinal point, where it ends posterior to the inguinal ligament by becoming the femoral artery. In the proximal part of its course it is medial to the psoas muscle; distally it lies anterior to the muscle The artery lies behind the peritoneum, and at its origin is crossed by the ureter. Crossing it anteriorly about 2·5 cm. (1 in) below its origin are the ovarian vessels and, at its lower end, the deep circumflex iliac vein and vas deferens (or the ligamentum teres) Proximally the genito-femoral nerve and testicular vessels are lateral to the artery but distally pass medially to lie on its anterior surface. The inferior epigastric and deep circumflex iliac branches arise close to its termination.

Technique.—The artery may be exposed by an extra-peritoneal approach or by the trans-peritoneal route The extra-peritoneal approach is utilized when it is desirable to secure control of the artery before operation for aneurysm in the proximal part of the femoral artery or in lesions of the lower third of the external iliac artery. When it is advisable to establish control of the termination of the common iliac artery or the origin of the external iliac, the trans-peritoneal approach is employed.

Trans-peritoneal Approach to the External Iliac Artery—With the patient in the Trendelenburg position a low paramedian incision is made, the intestines are displaced upwards and retained in position by packs. If the artery is to be exposed on the right side, its exact location is established by palpating for its pulsation by passing the finger along the brim of the pelvis. The posterior parietal peritoneum is then incised over the artery and the two peritoneal leaves are separated It is essential to make certain that the ureter has been displaced with the peritoneum. The sheath of the artery is then incised. On the left side the mesocolon overlies the artery so that the posterior peritoneum has to be incised vertically, close to the middle line, and then stripped laterally The opening in the peritoneum is sutured at the conclusion of the operation.

Extra-peritoneal Exposure of the External Iliac Artery.—The incision is made about 2·5 cm. (1 in.) above the inguinal ligament,

beginning just lateral to its mid-point and extending laterally and upwards beyond the anterior superior spine of the ilium. The superficial tissues are divided and the superficial epigastric and superficial circumflex iliac vessels are ligated and divided. The aponeurosis and muscular fibres of the external oblique, the internal oblique and transversus abdominis muscles, and the transversalis fascia are divided to expose the underlying peritoneum, which is stripped medially from the iliac fossa until the medial border of the

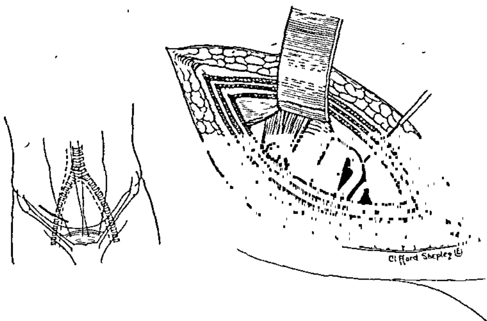


FIG 21 Exposure of External Iliac Artery by Extra-peritoneal Approach.

psoas muscle is exposed. The pulsations of the artery are sought along the medial border of the psoas muscle, and its sheath is opened. Care must be taken to avoid the ureter and the genitofemoral nerve.

The collateral circulation is dependent on the anastomoses of: the superior epigastric (from internal mammary) with inferior epigastric, the ilio-lumbar (from internal iliac) and last lumbar (from aorta) with the deep circumflex iliac; the internal pudendal (from internal iliac) with the external pudendal (from femoral), and branches of the gluteal arteries with those of the circumflex. Ligation of the external iliac artery distal to its branches cuts off the greater part of this circulation, and should be avoided.

FEMORAL ARTERY

The femoral artery courses from the mid-inguinal point to the opening in the adductor magnus at the junction of the middle and

lower thirds of the thigh; with the thigh slightly flexed, abducted, and rotated laterally, its course corresponds to the upper two-thirds of a line drawn from the mid-inguinal point to the adductor tubercle. About 3·5 cm. ($1\frac{1}{2}$ in.) below the inguinal ligament it gives off from its lateral side the large profunda femoris artery, which passes medially behind the femoral artery and the femoral and profunda veins and leaves the femoral triangle deep to the adductor longus muscle. The profunda artery gives off the medial and lateral femoral circumflex arteries. The femoral artery continues distally through the femoral triangle to its apex where it enters the sub-sartorial canal.

The lateral circumflex artery arises from the lateral aspect of the profunda, and runs between the branches of the femoral nerve to the lateral border of the femoral triangle where it passes deep to the sartorius and rectus femoris muscles; here it divides into its terminal (ascending, descending, and transverse) branches

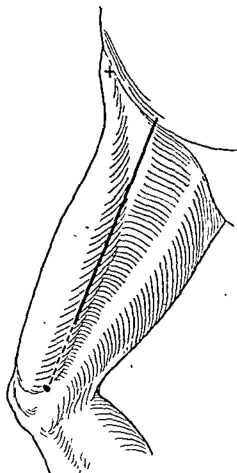
The medial circumflex artery arises at the same level as the lateral circumflex but from the postero-medial aspect of the profunda, and runs posteriorly between the psoas and pectineus muscles.

Technique.—The femoral artery can be readily exposed throughout its course by an incision in the anatomical line of the vessel. If the arterial lesion has been accurately localized, a portion of the exposure will suffice. In the femoral triangle localization of an aneurysmal varix is often impossible, and it may be necessary to explore the profunda artery or any of its branches, while associated injuries of the femoral trunk and the profunda artery are not uncommon.

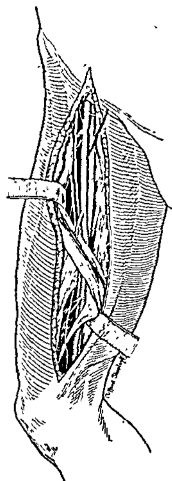
Control of the haemorrhage at operation may be secured by the application of a tourniquet if the distal portion of the artery is to be explored, but in lesions at the base of the femoral triangle it may be necessary as a preliminary step to expose the external iliac artery to establish provisional control of the circulation The abundant collateral circulation through the profunda and its branches makes it necessary to apply ligatures above and below any lesion in this area

To expose the Artery in the Femoral Triangle—The patient lies supine with the hip slightly flexed, abducted, and rotated laterally. The incision is made in the anatomical line of the artery The skin and superficial fascia are divided and the superficial lymph glands in the upper part of the incision are excised or held aside The long saphenous vein is seen passing to the saphenous opening to join the femoral vein. The lateral margin of the saphenous opening lies anterior to the femoral artery The long saphenous vein is preserved and retracted, and the fascia lata is then divided in the line of the incision to expose the sartorius muscle. The medial border of this muscle is freed and retracted to the lateral side. The upper 3 5 cm.

(1½ in.) of the artery lie in the femoral sheath, which is carefully picked up and opened. The femoral branch of the genito-femoral nerve which lies in its lateral wall in the upper part of the wound is avoided.



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FIG. 22. Line of Incision to expose the Femoral Artery.

FIG. 23. Dissection required to expose the Femoral Artery.

The femoral nerve lies lateral to the proximal part of the artery but outside the femoral sheath. Its medial cutaneous branch runs downwards and medially to pass in front of the femoral artery On the medial side of the upper portion of the artery lies the femoral vein, enclosed in a separate compartment of the femoral sheath; at the apex of the femoral triangle the vein comes to lie posterior to the artery Behind the femoral artery lie the muscles in the floor of the triangle (psoas, pectineus, and adductor longus) and the profunda vessels.

If the exposure and careful examination of the artery fail to reveal the lesion but temporary control of the proximal artery leads to the cessation of the thrill and bruit in aneurysmal varix, the fault lies in one of the branches and these must be displayed.

Exposure of the Profunda Femoris Artery—After the common femoral and upper part of the superficial femoral arteries have been exposed, the sartorius muscle is retracted to the lateral side. The femoral artery is then displaced to the medial side so that the origin of the profunda from its lateral side can be identified. As the profunda artery lies lateral to the femoral artery, the lateral circumflex vein lies superficial to it, while in the part of its course in which it runs posterior to the femoral artery the profunda and femoral veins intervene between it and the femoral artery. The profunda artery then leaves the femoral triangle by passing deep to the adductor longus muscle.

This exposure also reveals the *lateral circumflex artery*, which runs laterally on the iliacus muscle to pass deep to the rectus femoris and sartorius muscles. It lies in close relation to the branches of the femoral nerve.

The *medial circumflex artery* arises from the postero-medial aspect [illegible]

of the pectineus muscle.

To expose the Femoral Artery in the Subsartorial Canal.—The patient lies supine, with the hip and knee flexed, and the hip somewhat abducted and laterally rotated The incision is made in the anatomical line of the vessel in the middle third of the thigh The skin and fasciae are divided. The long saphenous vein may be encountered and should be preserved and retracted. The fibres of the sartorius muscle are identified by their downward and medial course, the lateral border of the muscle is identified, and the muscle is retracted to the medial side. This exposes the fibrous roof of the subsartorial canal through which the pulsations of the vessel can be felt. The canal is opened. The saphenous nerve lies anterior to the artery, the nerve to the vastus medialis on its lateral side. In the proximal part of the canal the femoral vein is posterior to the artery, towards the distal part postero-lateral

Lower Part of Femoral Artery and Upper Part of the Popliteal Artery.—This approach is indicated in lesions of the upper part of the popliteal artery and in those of the femoral artery close to the opening in the adductor magnus.

Technique.—With the patient supine, the limb is placed in position with the hip abducted, laterally rotated, and slightly flexed and the

knee in slight flexion. The adductor tubercle is identified and a vertical incision is made, beginning just distal to the adductor tubercle and passing upwards along the adductor tendon and then along the line of the artery as it courses in the subsartorial canal. The skin and superficial fascia are divided; the long saphenous vein may be in the line of the incision; it is freed and retracted. The deep fascia is incised in the same line and the antero-lateral border of the sartorius is defined. The deep surface of the muscle is mobilized and the muscle is retracted posteriorly. This exposes the fibrous roof of the subsartorial canal in the proximal part of the incision and the adductor magnus tendon distally. The saphenous nerve is seen leaving the subsartorial canal to run downwards in front of the adductor magnus tendon; it is accompanied by the saphenous branch of the descending genicular artery which arises from the femoral a short distance above the opening in the adductor magnus. These structures should be preserved. The roof of the subsartorial canal is divided close to the lateral border of the adductor tendon and the vessels are exposed. The roof of the subsartorial canal is retracted laterally, the adductor tendon medially, and the vessels are followed to the popliteal fossa, or the thin fascia posterior to the adductor tendon is picked up and divided to give free access to the popliteal fossa.

The relationships of the various structures are described in the exposure of the femoral and popliteal arteries.

Popliteal Artery

The popliteal artery begins at the opening in the adductor magnus as the continuation of the femoral artery and runs distally in the popliteal fossa between the condyles of the femur to end at the lower border of the popliteus muscle by dividing into the anterior and posterior tibial arteries. The popliteal vein lies postero-lateral to the artery in the upper part of the fossa, but crosses posterior to it to lie on its medial side in the lower part of the fossa. The medial popliteal nerve lies lateral to the beginning of the artery and the vein, but soon crosses them posteriorly to come to lie on their medial side. The posterior tibial artery runs downwards and medially from its origin; about 3·5 cm. ($1\frac{1}{2}$ in) distal to the popliteal bifurcation it gives off the peroneal artery which runs downwards and laterally. The anterior tibial artery runs downwards and forwards through the tibialis posterior muscle to pierce the upper part of the interosseous membrane and gain the anterior compartment of the leg.

Apart from muscular and cutaneous branches, the five genicular

arteries and the anastomoses between them are the only routes by which a collateral circulation can be established. If ligation must be carried out, the ligature should, if possible, be placed between the superior and inferior genicular arteries. Even at this level the

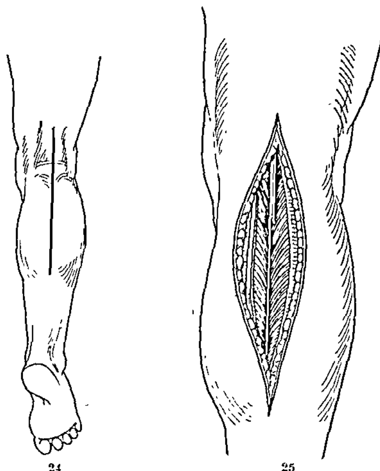


Fig. 24 Incision to expose the Lower Part of the Popliteal Artery and its Bifurcation

Fig. 25. Exposure of the Lower Part of the Popliteal Artery and its Bifurcation: Deepening of the Incision between the Two Heads of the Gastrocnemius Muscle.

collateral circulation is precarious and, if possible, operation should be postponed until the collateral circulation has had time to develop.

According to the site and nature of the lesion it may be necessary to expose the lower end of the femoral artery and the upper part of the popliteal, the popliteal artery, or the lower part of the popliteal artery and one or other of its terminal branches. The upper part of the exposure of the artery and its branches serves to display the

popliteal artery, but it is not possible by this method to expose more than the origin of its anterior tibial branch.

The Popliteal Artery and the Upper Parts of the Arteries of the Leg.—Technique.—The patient is placed in the prone position. The knee-joint is slightly flexed and the foot is plantar flexed to relax the calf



Fig 26. Exposure of the Lower Part of the Popliteal Artery and its Bifurcation: the Dissection completed

and hamstring muscles. A sandbag under the lower thigh helps to relax the hamstring muscles and the towels are so arranged that an assistant can control the limb and increase knee-flexion should this be necessary.

The skin incision begins at the junction of the middle and lower thirds of the thigh at the lateral border of the semimembranosus muscle and passes distally across the middle of the popliteal fossa and then slightly medially between the heads of the gastrocnemius

to end just distal to the bulge formed by the calf muscles. The short saphenous vein is seen in the superficial fascia of the back of the leg; it pierces the deep fascia in the popliteal fossa to join the popliteal vein. The posterior cutaneous nerve of the thigh emerges through the deep fascia behind the knee to run distally in the superficial tissues of the leg. These structures are preserved. The deep fascia is incised throughout the length of incision The sural branch of the medial popliteal nerve is found between the gastrocnemius muscle and the deep fascia, and should be preserved.

In the popliteal fossa the medial popliteal nerve is found in the fibro-fatty tissue; it is isolated and held gently to the lateral side in a loop of tape. In the upper part of the fossa the lateral popliteal nerve lies under cover of the edge of the biceps muscle; it passes laterally under the biceps muscle to the lateral angle of the fossa. This nerve need not be exposed in the dissection, but its sural communicating branch is seen running superficial to the lateral head of the gastrocnemius to pierce the deep fascia and join the sural nerve.

Retraction of the semimembranosus muscle to the medial side allows the dissection to be continued in the fatty tissue over the popliteal surface of the femur; the popliteal vein and artery are exposed after the sheath has been opened.

In the lower part of the incision the two heads of the gastrocnemius muscle are separated by dissection, care being taken to spare their arterial supply from muscular branches of the popliteal artery which enter their deep surface close to the line of separation. The branch from the medial popliteal nerve to the medial head of the gastrocnemius is carefully separated proximally and is gently retracted to the medial side while the medial popliteal nerve is gently held in a tape loop to the lateral side The popliteal vessels are now seen passing distally under cover of the arched upper border of the soleus muscle This muscle is carefully raised on a dissector and divided in the middle line. The soleus is retracted to expose the bifurcation of the popliteal the origin of the peroneal artery must not be mistaken for the bifurcation The anterior tibial artery is the smallest vessel and takes origin from the anterior surface of the popliteal. The posterior tibial continues for a short distance and then gives off the peroneal artery which may be as large or even larger than the posterior tibial The anterior tibial artery may be followed for a short distance by dividing the fibres of the tibialis posterior and enlarging the opening in the interosseous membrane

The wound is closed by suture of the skin; during the post-operative period the limb is kept with the knee extended and the foot at right angles.

While this exposure gives satisfactory access to the vessels of the posterior compartment of the leg, it does not permit the adequate investigation of the upper arched portion of the anterior tibial artery. A. K. Henry has described a method by which this can be done. If the exploration of the popliteal bifurcation shows that the lesion is in the upper portion of the anterior tibial artery, the posterior incision is temporarily covered and the position of the limb is altered so that the foot lies with its medial edge across the ankle of the sound side. The interval between the tibia and fibula is then palpated and a vertical incision is made beginning above at the apex of the arch formed by the junction of the two bones of the leg. This incision divides the deep fascia in the same line. The interval between the tibialis anterior and the extensor digitorum longus muscles lies in this line, and it is opened up. When the tibialis anterior muscle is retracted anteriorly and the long extensor posteriorly, the anterior tibial vessels and nerve are seen under cover of the long extensor. At this level the nerve lies to the lateral side of the artery. The artery is displayed in the length of the incision; the anterior tibial recurrent branch arises from the front of the artery just distal to the opening in the interosseous membrane; it is ligated and divided. The opening in the membrane is incised, and it is then possible to draw the arched portion of the vessel into the posterior incision.

The Posterior Tibial and Peroneal Arteries

The *posterior tibial artery* arises at the lower border of the popliteus and passes almost vertically over the tibialis posterior and flexor digitorum longus muscles, and the lower part of the posterior surface of the tibia, to end midway between the tip of the medial malleolus and the medial tubercle of the calcaneus In its upper two-thirds it lies deep to the calf muscles; in its distal third it is superficial; at its termination it passes deep to the flexor retinaculum.

The *peroneal artery* arises about 2·5 cm. (1 in.) below the bifurcation of the popliteal and runs downwards and laterally to gain the medial surface of the fibula, along which it runs distally deep to the soleus and flexor hallucis longus muscles It ends on the calcaneus below the lateral malleolus.

Technique.—The patient lies prone with the knee somewhat flexed and the foot plantar flexed to relax the tension of the calf muscles The incision is made slightly to the medial side of the midline of the leg beginning about 3 cm. (1¼ in.) below the bend of the knee. It is continued distally in this line over the fleshy bellies of the calf muscles, and then deviates to the inner border of the tendo calcaneus to end within 2·5 cm (1 in.) of the insertion of that tendon into the calcaneus. The short saphenous vein and the sural nerve are

identified in the superficial fascia, and drawn to the lateral side. The deeper dissection is begun in the lower part of the wound by dividing the deep fascia along the medial border of the tendo calcaneus. The left index finger is inserted deep to the tendon, and

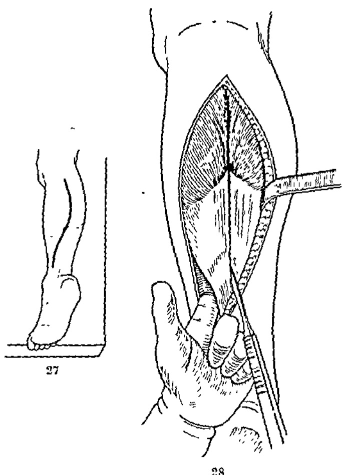


FIG. 27. Exposure of Posterior Tibial and Peroneal Arteries Position of Limb and Incision

FIG. 28. Exposure of Posterior Tibial and Peroneal Arteries Method of Finding the Plane of the Vessels

passed proximally to identify the plane in which the vessels run The heads of the gastrocnemius are separated in the upper part of the wound and the soleus muscle is then elevated on the index finger and divided with scissors throughout the length of the incision The fibrous arch which forms its upper border must be included in the division. The divided calf muscles are then retracted, and the layer of fascia overlying the vessels is divided. The posterior tibial artery

lies with its venae comitantes closely apposed to it, and the posterior tibial nerve lies on the medial side of its proximal 3 cm. (1¼ in.) on the lateral side below this level. The peroneal artery and its venae comitantes are found under cover of the lateral muscle flap and deep

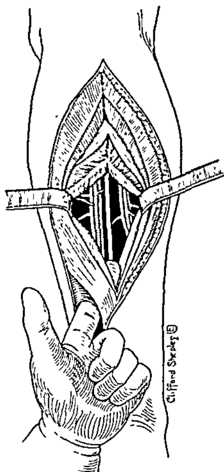


FIG. 29. Exposure of Posterior Tibial and Peroneal Arteries· Dissection completed

to a layer of fascia The close adhesion of the venae comitantes to these arteries may make it necessary to include them in the ligature.

The wound is closed by suturing the divided calf muscles and the upper expanded portion of the tendo calcaneus with interrupted non-absorbable sutures If drainage is required, it is advisable to bring the drain out through the distal part of the wound.

ANTERIOR TIBIAL ARTERY

The anterior tibial artery arises at the lower border of the popliteus. It passes forwards and distally through the upper part of the tibialis

posterior and pierces the interosseous membrane. It then runs distally on the anterior surface of the interosseous membrane and of the lower part of the tibia Its course is marked by a line running from a point midway between the lateral condyle of the tibia and the head of the fibula to a point in front of the ankle midway between the two malleoli, here it becomes the dorsalis pedis artery.

Technique—The artery may be exposed in the anterior compartment of the leg, but this approach does not give access to its point of origin from the popliteal artery. With the patient supine and the knee extended, an incision is made in the line of the vessel. The deep fascia is divided, the interval between the tibialis anterior and extensor digitorum longus muscles is defined in the middle of the leg and these muscles are separated and retracted throughout the length of the incision. In the upper half of the leg this displays the neurovascular bundle. In the lower half the extensor hallucis longus muscle and its tendon are exposed lying lateral to the neurovascular bundle above; as the tendon passes distally, it crosses the vessels to lie on their medial side in front of the ankle. This muscle is retracted laterally In the upper two-thirds of the leg the vessels and nerve lie on the interosseous membrane within a cylinder of fatty tissue, on the tibia in the lower third

Dissection of the neurovascular bundle exposes the anterior tibial artery with its venae comitantes, and the anterior tibial nerve. The latter lies lateral to the artery in the upper third of the leg, superficial to it in the middle third, and lateral to it in the lower third.

The main difficulty is to define the septum between the tibialis anterior and extensor digitorum longus muscles; the incision in the deep fascia should be strictly in the line of the vessels.

The collateral circulation from the posterior tibial and peroneal arteries is abundant, and ligation of the anterior tibial artery is safe at any level.

J. J. M. B

CHAPTER III

OPERATIONS ON PERIPHERAL NERVES

Nerve Suture. Neurolysis. Operations on Nerves of Upper and Lower Limbs. Operations on Autonomic Nerves.

Operations on peripheral nerves may be necessary (*a*) to restore the continuity of a nerve divided in a wound or torn by excessive traction, and (*b*) to restore conductivity in a nerve whose continuity has not been interrupted, but whose internal architecture has been destroyed by bruising to such an extent that the whole or a part of its function is lost; such a lesion may be perpetuated, or increased in severity, by the presence of surrounding scar tissue.

Restoration of Continuity of a Nerve: Nerve Suture.—Success in nerve suture depends upon attention to these cardinal principles. First, the cut surface of the proximal segment must show normal fasciculi, permitting the unrestricted down-growth of axones, and the cut surface of the distal segment must not be so fibrosed that these axones cannot enter and traverse its Schwann tubes, and mature within them. Moreover, the surfaces to be approximated must be of nearly the same shape and of nearly the same area. Second, the sutures used must be fine and non-irritating, and they must traverse the nerve sheath, and the nerve sheath alone. Third, the suture must be carried out at a date after injury early enough to allow the down-growing axones to reach their endings in muscle and in other end-organs before fibrosis has eliminated all possibility of functioning reconnexion. Fourth, the suture line must not be under tension.

Prior to the war of 1939–45 it was the view that these criteria were best satisfied by immediate (primary) suture in an operative field which was sterile, or could be rendered sterile. Experience has modified this view, for reasons which have been assembled by Seddon and by Zachary: (*a*) within a few hours of the injury, in all save the sharpest of incised wounds, it is difficult to assess the longitudinal extent of the damage to the nerve, and failure to recognize and excise damaged nerve-tissue may leave a fibrosed segment of nerve which blocks the outgrowth of axones; (*b*) the outgrowth from the peripheral segment of Schwann cells, which guide the outgrowing axones into it, is greatest about the third week after division of the nerve; (*c*) some weeks after division the nerve sheath has become tougher, and therefore can be sutured more accurately and more securely; and (*d*) in order to suture the ends without tension it is usually necessary to mobilize the nerve; this further dissection is

justifiable only when time has shown that the sterility of the wound is beyond doubt; moreover, the suture line will not then lie (as is likely in immediate suture) in a zone of scar tissue.

From these considerations it is possible to formulate certain advice in the treatment of divided nerves:

(1) When a divided nerve is found in a wound in which the other divided structures are to be sutured immediately, its ends should be approximated by two sutures to preserve the orientation of the cut surfaces, and prevent their retraction. If the wound remains aseptic definitive nerve suture is performed after an interval of three to four weeks.

(2) In all other cases the primary effort must be to secure sound healing To aid in this there are available chemotherapy (the sulphonamides, penicillin) and skin-grafting Nerve suture is carried out as soon as possible after the wound has healed; with prophylactic chemotherapy before the second operation we have found an interval of three weeks to be adequate. The more the interval between the receipt of the injury and nerve suture exceeds about five months the less satisfactory is the final result likely to be.

(3) When, from the site of the wound, it is possible that a nerve has been divided it should be explored as soon as possible, except when there is *clear* and *progressive* evidence of restoration of conduction

(4) In the period before nerve suture, and until voluntary recovery is adequate, measures must be taken to prevent the stretching of paralysed muscles, to maintain their nutrition by physiotherapy, and to retain full range of movement at all joints and in all tendon-sheaths affected by the nerve lesion.

Technique of Nerve Suture.—Most surgeons employ general anaesthesia, but local infiltration anaesthesia with 0·5 per cent. novocain is also satisfactory The whole of the limb should be

incision in its anatomical line, extending both proximal and distal to the level of division, any previous cutaneous scar being excised The nerve is identified in normal anatomical surroundings proximal and distal to the lesion, and isolated by tapes moistened with sterile normal saline solution Dissection of the nerve must proceed with the utmost gentleness and without tension upon it, any instrument employed to hold it must be fine, and applied to the sheath alone. The proximal and distal dissections are connected, care being taken to preserve all branches from both segments; finally, the severed ends are identified and freed The proximal end will be

bulbous ('end-bulb'), the distal tapering, lost in a mass of scar tissue. To prevent the final anastomosis being made with either segment rotated, guide sutures of fine silk on atraumatic needles are placed in the sheath, diametrically opposite each other, at corresponding points on both segments where they appear and feel normal.

The faces of the segments are now prepared for anastomosis by removing slices from each segment; this is best done by a safety-razor blade, held in artery forceps. The face of the proximal segment

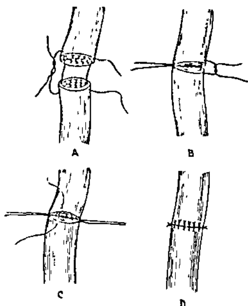


FIG 30 Stages in Nerve Suture.

should show the fasciculi of the nerve, without surrounding fibrosis or oedema; the face of the distal segment should be 'cut back' until it is clear of surrounding scar tissue and intraneural fibrosis is minimal. When the faces have been prepared a gap will remain which varies in length according to the primary loss of nerve tissue, according to the time which has elapsed since the injury, and according to the presence and severity of previous sepsis. The

used to approximate the faces, when this can be achieved without any expedient other than mobilization of the nerve the stays are tied and their ends secured by mosquito forceps. The anastomosis is completed by interrupted sutures through the approximated sheaths, inserted so as not to invert them, and not more numerous than are required for neatness. These sutures should not crush the

faces together; what is needed is approximation. Usually it is more convenient to insert the posterior sutures first; to enable this to be done the faces are rotated by the stay sutures, one of which is passed under the nerve and pulled upon. When the posterior row of sutures has been inserted the nerve is rotated to its anatomical position, and the anterior row is completed. Every effort is then made to secure that the line of anastomosis will lie in an intermuscular cleft; or, if this is not possible, at least not in the vicinity of any previous scar. Haemostasis is completed, and the fascial planes and skin are sutured. The limb is immobilized for three weeks in a position in which the anastomosis is relaxed, a light plaster-of-Paris case is the most generally useful splint.

Occasionally, when a nerve has been only partly divided, it is possible to isolate the strand involved and to deal with it as indicated above, the remainder of the nerve being left intact; we have used this method in lesions of the outer head of the median, after its junction with the main nerve.

While fine silk is commonly used for nerve suture, other non-irritating materials (tantalum wire, human hair) have been successfully employed; catgut should not be used.

When the gap between the segments is so great that their ends cannot be apposed by gentle traction on the stay sutures, the difficulty may be overcome (*a*) by further mobilization of the nerve above and below the lesion, branches of the proximal segment which anchor it being gently separated proximally from the main trunk, and in extreme cases the most proximal branches of the distal segment being divided; (*b*) by fixing the segments of a limb in positions which shorten the total distance to be traversed by the nerve: thus for the median nerve, the forequarter is elevated towards the neck, the arm adducted and internally rotated, the elbow and wrist joints flexed; (*c*) by changing the nerve to a more direct course. thus the ulnar nerve may be transplanted (p. 70) from the back to the front [illegible]

[illegible]

nerve to be repaired, the grafts are obtained from the patient's relatively unimportant cutaneous nerves (e g. the lateral cutaneous nerve of the thigh). A single strand suffices if the graft is to be inserted into a nerve of its own calibre—for example, a digital nerve in the palm or finger; when the host nerve is large, the graft is made up to the required size by inserting several strands of the required length ('cable' graft). A single nerve suture is passed through the sheath at each end of each component strand of the graft, the strand

is fitted in position, and the sutures passed through the sheath of the host nerve at approximate corresponding points of its proximal and distal faces. 'Single strand' grafts are much more successful than the 'cable' variety.

Restoration of Conductivity in a Nerve: Treatment of Lesions in Continuity.—Lesions in continuity may result from various forms of trauma: (*a*) severe pressure of short duration, as in crutch paralysis of the radial nerve; (*b*) bruising at the site of a fracture, for example, of the radial nerve in fracture of the humerus; (*c*) the commotion occasioned by the passage of a high-velocity missile; (*d*) long-continued slight pressure, for example, on the lowest trunk of the brachial plexus by a cervical rib, on the ulnar nerve in its groove behind the medial epicondyle of the humerus, on any nerve by scar tissue; and (*e*) the inaccurate injection of drugs (e.g. sulphonamide drugs) when an intended intramuscular injection is made into the nerve. In some of these conditions clinical experience indicates that spontaneous recovery is to be expected (crutch paralysis) or that the source of pressure should be dealt with (cervical rib). There remains a group, which is considerable in war injuries, in which, in the absence of *early* and *progressive* evidence of recovery, the proper course is to explore the nerve; only by direct exposure can the true state of affairs be established and the appropriate treatment applied. In such circumstances it may be stated, without going into detail, that one of two conditions will be found: (*a*) a nearly normal nerve is being strangled by scar tissue: the nerve should be freed, scar tissue excised so far as is possible, and the nerve placed in a normal intermuscular plane (*neurolysis*); and (*b*) the nerve is enlarged, perhaps ragged, and perhaps adherent to other nerves or to a blood-vessel. The pathological lesion is fibrosis within the nerve sheath. Much judgement is required in determining the proper procedure: the decision is based (*a*) on the results of direct stimulation of the nerve; (*b*) on the relative hardness of the lesion; and (*c*) on the particular function of the nerve which is lost or partly lost. Thus the production of contraction in muscles innervated by the nerve is evidence that some fibres are conducting and might encourage conservatism, or at least a further period of observation. Relative hardness of the nerve at the site of the lesion, on the other hand, suggests that radical treatment (resection and suture) is in the best interest of the patient. Preservation of considerable motor function, with loss of sensory function, in the case of the ulnar nerve is an indication to leave well alone. Moreover, there are two overriding considerations: (*a*) that pathologically fibrosis is usually a progressive lesion, and (*b*) that the nearer the root of the limb a lesion is situated, the less perfect are the results of resection and

suture. When a decision has been reached the alternatives are neurolysis (p. 67) and resection of the lesion and suture (p. 64); after both procedures adequate physiotherapy is necessary.

THE SURGERY OF INDIVIDUAL NERVES

The Nerves of the Upper Limb

Brachial Plexus.—On the whole the results of attempts to repair the roots of the brachial plexus have been disappointing Traction lesions involving the fifth and sixth cervical nerves or their union to form the upper trunk of the plexus are the most accessible. The incision runs parallel and immediately anterior to the posterior border of the lower half of the sternomastoid muscle, continues in the same line to the upper border of the second rib, and then passes posteriorly for 10 cm. (4 in.). Skin, platysma, and deep fascia are reflected laterally in a triangular flap, which includes the suprasternal and supraclavicular branches of the cervical plexus. The omohyoid is identified and divided, and any transversely directed vessels which impede access are divided between ligatures The dissection to disclose and isolate the injured nerves is carried out between the scalenus medius and scalenus anterior muscles; the roots of the plexus emerge at the lateral border of the latter The lesion is identified and if possible repaired There is very little 'slack' in this part of the plexus, but a short gap may be overcome by strong elevation of the forequarter and lateral flexion of the neck towards the injured side, a position which must be strictly maintained by a plaster-of-Paris cast for four weeks, until healing of the sutured nerve is secure.

The *cords* and *terminal branches* of the plexus are more easily repaired; they are displayed fully by the operation described on p 40 for the exposure of the subclavian and axillary arteries The same posture is used to relieve tension as is described in the preceding paragraph.

Circumflex Nerve.—The origin of the circumflex nerve from the posterior cord of the brachial plexus is exposed by the dissection referred to in the preceding paragraph To display its branches to the deltoid muscle, the patient is placed prone or on his uninjured side. An incision 20 cm (8 in.) long is made, its mid-point opposite the junction of the upper and middle thirds of the posterior border of the deltoid muscle. The posterior margin of the incision, including the deep fascia, is undercut, and the posterior border of the deltoid is defined and retracted anteriorly, this exposes the tendons of the teres minor and long head of triceps muscles. The terminal part of

the nerve, accompanied by the posterior circumflex humeral artery, emerges between the teres minor and the surgical neck of the humerus, and enters the deep aspect of the deltoid muscle.

Musculo-cutaneous Nerve.—Only the muscular branches (to the coracobrachialis, biceps, and brachialis muscles) are of importance. The trunk of the nerve is exposed as it lies to the lateral side of the third part of the axillary artery (p. 40).

Median Nerve.—As far distally as the cubital fossa the nerve is exposed by the incisions described on pp. 43–4; its proximal part, which does not give off any branches, can be extensively mobilized. The upper 'crucial point' on the median nerve is at the level where, under cover of the pronator teres muscle, it supplies a leash of branches to the flexor-pronator group. To effect repairs in this region a wide exposure is necessary: the primary dissection is described on p. 44. It may be necessary temporarily to detach the insertion of pronator teres and retract the muscle medially. The lesion must be defined cautiously and methodically, particular care being given to locating and if need be securing the numerous vessels in the area, so that the anastomosis is left in a perfectly dry field. At the end of the operation the insertion of the pronator teres is repaired by interrupted silk sutures. If further distal mobilization is necessary, the cutaneous incision (p. 45) is prolonged in the interval between the palmaris longus and flexor carpi radialis muscles.

The lower 'crucial point' on the nerve is about the level of the wrist-joint, where in civil practice the nerve is not uncommonly involved—often with adjacent tendons—in cuts from broken glass. In such injuries the procedure described on p. 45 is adopted, the proximal segment of the nerve being mobilized through a longitudinal incision beginning between the insertions of palmaris longus and flexor carpi radialis and directed towards the mid-point of the cubital fossa. As it enters the carpal tunnel the nerve becomes flattened, and if the nerve has been divided at that level some attention is necessary to secure good apposition of the dissimilar faces of the segments. If the anastomosis lies in the carpal tunnel, the flexor retinaculum should not be repaired.

Ulnar Nerve.—In the arm the ulnar nerve does not furnish any branches. It accompanies the brachial artery as far as the middle of the arm; then, with the ulnar collateral artery, it inclines posteriorly along the medial border of the triceps muscle, traverses the tunnel formed by the groove on the posterior aspect of the medial epicondyle of the humerus and its tough aponeurotic roof, enters the forearm between the two heads of the flexor carpi ulnaris, and runs distally upon the flexor digitorum profundus towards the lateral border of the pisiform bone. At the junction of the upper and

middle thirds of the forearm it is joined, on its lateral side, by the ulnar artery (p. 45). Throughout its entire course the nerve is best displayed through an incision which follows its anatomical line.

The length traversed by the nerve may be substantially shortened so that loss of its substance may be compensated by transplanting it to the anterior aspect of the elbow joint. Ulnar transposition is also required for the relief of 'tardy ulnar palsy', a lesion-in-continuity of the nerve where it occupies the epicondylar groove (p. 69); this is the result—often after a long latent interval—of some bony lesion at the lower end of the humerus. The usual lesion has been an incompletely reduced fracture of the lateral condyle, which has been followed by cubitus valgus; but the groove may be involved in callus, and occasionally the nerve is so loosely retained in the groove that it dislocates anteriorly when the elbow is flexed.

Technique of Ulnar Transposition.—An incision is made in the line of the nerve, from the middle of the arm to the upper third of the forearm. The nerve is isolated in the whole length of this incision, its branch or branches to the elbow joint being divided, and, if necessary, also the twig to the ulnar head of flexor carpi ulnaris. The branches to flexor digitorum profundus and the branch to the humeral head of flexor carpi ulnaris arise more distally; they are carefully freed distally in these muscles and are also separated proximally from the trunk of the nerve The numerous branches of the periarticular vascular anastomosis are secured as they are encountered. The next step is to remove the medial intermuscular septum as it bridges the interval between the humerus and the medial epicondyle, in order to provide an uninterrupted new course for the nerve. The upper border of pronator teres is then defined, and a blunt instrument is passed under the flexor pronator group of muscles, to appear on the lateral aspect of the nerve in the upper part of the forearm, the tunnel so made is enlarged by opening the blades of a forceps. If the nerve has been divided and it is clear that the level of the anastomosis will not be under cover of the muscles, the appropriate segment of the nerve is drawn through the tunnel *before its end is freshened.* In other cases, and when the nerve is in continuity, the origin of the flexor-pronator group is divided and raised laterally. If it is intact, the nerve is laid in its new intermuscular bed, to the medial side of the median nerve; if divided, the nerve is repaired as it lies in its new line. The origin of the flexor-pronator group is restored with interrupted silk sutures; the interval between humeral and ulnar heads of the flexor carpi ulnaris muscle is approximated and the cutaneous incision is closed. The arm is maintained in flexion at the elbow joint for three weeks and then gradually allowed to straighten over a further two weeks.

Branches of Median and Ulnar Nerves in the Palm and Digital Branches.—Wounds of the palm and of the fingers often involve the terminal branches of the median and ulnar nerves, and every effort should be made to repair these nerves by suture or by nerve-graft. From the point of view of function, the sensory branches of the median and the motor branch of the ulnar are the most important.

Sensory Branches of Median Nerve.—In the distal part of the carpal tunnel the median nerve divides into a lateral and a median division. The lateral division provides the branch to the muscles of the thenar eminence, the palmar digital nerve to the lateral side of the thumb, and the palmar digital nerve which supplies the medial side of the thumb and the lateral side of the index finger. The medial division branches into two palmar digital branches which bifurcate to supply the adjacent sides of the index and middle, and middle and ring fingers. The common digital branches are sought as they lie on the anterior surface of the corresponding lumbrical muscles. The dissection should be made with the aid of a tourniquet; the longitudinal incision to expose the median nerve above the carpal tunnel is extended into the palm, and continued obliquely laterally in the line of a suitable palmar crease.

Deep Terminal Branch of Ulnar Nerve.—The deep terminal branch of the ulnar nerve is the motor nerve to the majority of the small muscles of the hand; it is important for the execution of delicate movements. It is the medial of the two branches in which the ulnar nerve terminates anterior to the flexor retinaculum, at the lateral border of the pisiform bone. Entering the palm between the abductor and the short flexor of the fifth finger, it turns deep to the latter muscle obliquely laterally towards the metacarpo-phalangeal joint of the thumb. Early repair of lesions of this nerve is followed by valuable functional results. The technique is similar to that described in the preceding paragraph.

Radial Nerve.—The origin of the radial nerve from the posterior cord of the brachial plexus is exposed by the dissection described on p. 46. The trunk leaves the medial side of the arm to wind round the humerus, with the profunda brachii artery, in a groove in the bone, pierces the lateral intermuscular septum, and continues between the brachialis muscle medially and the brachio-radialis laterally to the lateral epicondyle, where it divides into the radial and the posterior interosseous nerves. The branches for the triceps muscle leave the trunk in the axilla, so that this muscle often escapes paralysis in the usual lesion of the nerve in civil practice—involvement in fracture of the shaft of the humerus. When this lesion requires operative treatment it is wise to be prepared to display the

middle thirds of the forearm it is joined, on its lateral side, by the ulnar artery (p. 45). Throughout its entire course the nerve is best displayed through an incision which follows its anatomical line.

The length traversed by the nerve may be substantially shortened so that loss of its substance may be compensated by transplanting it to the anterior aspect of the elbow joint. Ulnar transposition is also required for the relief of 'tardy ulnar palsy', a lesion-in-continuity of the nerve where it occupies the epicondylar groove (p. 69); this is the result—often after a long latent interval—of some bony lesion at the lower end of the humerus. The usual lesion has been an incompletely reduced fracture of the lateral condyle, which has been followed by cubitus valgus; but the groove may be involved in callus, and occasionally the nerve is so loosely retained in the groove that it dislocates anteriorly when the elbow is flexed.

Technique of Ulnar Transposition.—An incision is made in the line of the nerve, from the middle of the arm to the upper third of the forearm. The nerve is isolated in the whole length of this incision, its branch or branches to the elbow joint being divided, and, if necessary, also the twig to the ulnar head of flexor carpi ulnaris. The branches to flexor digitorum profundus and the branch to the humeral head of flexor carpi ulnaris arise more distally; they are carefully freed distally in these muscles and are also separated proximally from the trunk of the nerve. The numerous branches of the periarticular vascular anastomosis are secured as they are encountered. The next step is to remove the medial intermuscular septum as it bridges the interval between the humerus and the medial epicondyle, in order to provide an uninterrupted new course for the nerve The upper border of pronator teres is then defined, and a blunt instrument is passed under the flexor pronator group of muscles, to appear on the lateral aspect of the nerve in the upper part of the forearm; the tunnel so made is enlarged by opening the blades of a forceps. If the nerve has been divided and it is clear that the level of the anastomosis will not be under cover of the muscles, the appropriate segment of the nerve is drawn through the tunnel *before its end is freshened.* In other cases, and when the nerve is in continuity, the origin of the flexor-pronator group is divided and raised laterally. If it is intact, the nerve is laid in its new inter-

[illegible]

between humeral and ulnar heads of the flexor carpi ulnaris muscle is approximated and the cutaneous incision is closed. The arm is maintained in flexion at the elbow joint for three weeks and then gradually allowed to straighten over a further two weeks.

The upper part of the sciatic nerve is exposed by the same dissection as that for the arteries of the buttock (p. 48); the lower part through a 7-shaped incision, the longitudinal part of which is placed in the midline of the thigh, from the popliteal fossa to the lower border of the gluteus maximus muscle, where it sweeps laterally to join the beginning of the incision to expose the upper part. The whole length of the medial popliteal nerve is exposed through a [illegible]

[illegible]

biceps femoris muscle and tendon. A lesion of the trunk of the sciatic nerve may be limited to one of its two parts, usually the lateral popliteal component; thus it is often possible to confine resection and suture to one part.

The sciatic nerve and its branches are relieved from tension when the limb is fixed in a plaster-of-Paris case, with the hip-joint extended, the knee-joint flexed, and the foot plantar-flexed.

Obturator Nerve.—The obturator nerve supplies the adductor group of muscles; both nerves are sometimes resected to overcome bilateral adductor spasm

Bilateral obturator section is best performed upon the nerves while they are intrapelvic. The patient is placed in the Trendelenburg position, and a median incision made between umbilicus and pubes. The recti muscles are separated and held apart by a self-retaining retractor. The peritoneum is displaced from the antero-lateral wall of the pelvis, the obturator foramen is identified, and the nerve is isolated from the obturator artery and its venae comitantes which are inferior to it. About 5 cm. (2 in.) of the nerve are resected, first on one side, then on the other The peritoneum is allowed to fall back into its normal position, the operating table is levelled, and the abdominal wound is closed.

THE AUTONOMIC NERVOUS SYSTEM

Anatomy and Physiology.—At present, operations on the autonomic nervous system are practically limited to its *thoracicolumbar* (*sympathetic*) component. The important structure in this component is the paravertebral gangliolated chain, which lies on the sides of the vertebrae from the base of the skull to the tip of the coccyx. At intervals the chain is expanded to form ganglia, of which there are three in the cervical region, twelve in the thoracic region, four in the lumbar region, and four [illegible] connected to the spinal cord, from the [illegible] segment inclusive, by white rami comr[illegible] preganglionic efferent fibres and a certain number of afferent fibres. After traversing the chain for varying distances, the preganglionic efferent fibres form synapses with several cells in a ganglion of the chain, or leave the chain to

radial nerve on both medial and lateral aspects of the arm. On the *medial* aspect the neurovascular bundle is displayed by the exposure for the third part of the axillary artery (p 40). The profunda brachii vessels are identified as they leave the postero-lateral aspect of the brachial artery; after retraction of the neurovascular bundle and the profunda vessels in a postero-medial direction, the radial nerve appears as it traverses its oblique course on the tendon of the latissimus dorsi muscle towards the groove on the humerus. To display the nerve on the *lateral* aspect the arm is laid upon the chest, with the elbow flexed; the incision begins immediately above the elbow-joint, in the groove between the brachio-radialis and brachialis muscles, and follows the course of the nerve proximally. The nerve is identified distally, where it supplies (from its lateral side) branches to the brachio-radialis and extensor carpi radialis longus muscles, and followed proximally by separating the long and lateral heads of the triceps muscle. The distance to be traversed by the nerve is least when the forequarter is elevated, the arm adducted and rotated laterally, and the elbow-joint flexed.

The *posterior interosseous* branch of the radial nerve winds round the neck of the radius in the substance of the supinator muscle, and on its emergence breaks up into branches for the supply of the extensor-abductor group of muscles It is exposed through a longitudinal incision in a line from the lateral epicondyle of the humerus to the tuberosity of the radius, this corresponds to the interval between the extensor carpi radialis brevis and extensor digitorum muscles; by deepening the incision through the aponeurosis at the proximal end of this incision the termination of the nerve is displayed.

The Nerves of the Lower Limb

Sciatic Nerve.—At its exit from the pelvis, through the great sciatic foramen below the piriformis muscle, the sciatic nerve lies under the gluteus maximus muscle on the spine of the ischium, the sciatic artery and the posterior cutaneous nerve of the thigh being to its medial side. In its course to the popliteal fossa the hamstring muscles are posterior to it, and the adductor magnus muscle immediately anterior. The medial and lateral popliteal nerves, of which it is composed, have a common loose sheath, but proximally are always separable to the pelvis. The level of bifurcation of the sciatic nerve varies: the medial popliteal runs distally, in the midline of the posterior aspect of the thigh, and reaches the calf under the fibrous arch of the soleus muscle; the lateral popliteal deviates laterally, postero-medial to the tendon of the biceps femoris muscle, and winds round the neck of the fibula to reach the anterior compartment of the leg

anaesthesia is best. The patient is placed in the 'kidney' position, and tilted a little towards the operator. The incision begins in the angle between the twelfth rib and the sacrospinalis muscle, and follows the lower border of the rib to end at the outer border of the rectus muscle; if the rib is long it is helpful to remove it. The lateral border of the latissimus dorsi muscle is retracted posteriorly, and the flat muscles of the abdominal wall are separated or divided for 10 cm. (4 in.) anteriorly to expose the peritoneum. The peritoneum is displaced medially from the posterior abdominal wall to display the psoas muscle, on the surface of which the genito-femoral nerve passes obliquely towards the thigh. The sympathetic chain lies on the lateral aspect of the bodies of the lumbar vertebrae, along the medial margin of the psoas muscle, overlapped by the aorta on the left side and by the inferior vena cava on the right side. It is brought into view by the hand of an assistant, which displaces peritoneum and vessel medially, and defined from the point where it disappears under the external iliac artery (left side) or common iliac vein (right side). Cranially the chain disappears under the lumbocostal ligament, which is divided to expose the first lumbar ganglion lying under it. The chain is divided cranial to this ganglion, elevated in a caudal direction, its branches being cut with long scissors as they are encountered, and finally divided caudal to the third lumbar ganglion. On the right side it may pass posterior to one or more of the lumbar veins. All bleeding-points are secured and the wound is closed in layers, without drainage. The opposite chain may be dealt with similarly in seven days. In the male a bilateral operation of this type may be followed by loss of ejaculatory power; erection is not impaired.

Resection of the Superior Hypogastric Plexus (Presacral Nerve).—This operation is successfully employed in the treatment of primary dysmenorrhoea. A majority of the afferent fibres from the uterus traverse the superior hypogastric plexus, which is composed of mesially directed branches of the lumbar sympathetic ganglia, and lies on the anterior aspect of the fifth lumbar vertebra, immediately under the peritoneum. Caudally the plexus divides, one half passing to each hypogastric ganglion.

Technique.—Spinal anaesthesia is best. The patient is placed in the Trendelenburg position, and the abdomen is opened through a left subumbilical paramedian incision. The intestines are displaced from the pelvis A vertical incision 5 cm. (2 in.) long is made through the peritoneum overlying the fifth lumbar vertebra, and the edges of this incision are separated, care being taken on the left side to displace the superior haemorrhoidal artery. The strands of the plexus run irregularly in the area bounded on the left by the left

reach (by way of the splanchnic nerves) one of the large visceral ganglia. In these ganglia each preganglionic fibre forms synapses with several postganglionic fibres, which are ultimately distributed (a) to the limbs along the somatic nerves, which they join as grey rami communicantes, and (b) to the viscera. This efferent system is destined for (a) the smooth muscle in blood-vessels and viscera, (b) sweat glands, and (c) the muscles of the hairs; in addition, (d) a proportion of afferent fibres follow the same routes. Most operations on the sympathetic system are designed to abolish vasoconstrictor tonus; occasionally it is desired to abolish sweating, occasionally to interrupt afferent fibres, and occasionally (possibly) to interrupt the nerve-supply to the adrenal gland. In the majority of denervations the lesion for which operation is carried out is in a limb; the most effective denervation results from interruption of preganglionic fibres. The preganglionic fibres for the upper limb join the paravertebral chain from the fourth to the tenth thoracic segments, those for the lower limb from the twelfth thoracic to the second lumbar segments.

Denervation of Limbs.—This is performed for vasospastic disease, occasionally for hyperidrosis. The decision to operate is reached only after certain special tests (outwith the scope of this book) have been satisfied.

Upper Limb.—Endotracheal anaesthesia is employed. The patient lies on the sound side. The space between the second and third thoracic spinous processes is identified, and a paravertebral incision 10 cm. (4 in.) long and 5 cm (2 in) from the middle line is made, equally cranial and caudal to this point. The muscles are divided in the same line until the third rib is identified; it is cleared for 5 cm. (2 in.) laterally, and this segment is removed. The vertebral transverse process and the medial remaining segment of rib are then exposed and removed. The second and third intercostal nerves are identified and isolated. The pleura is now gently disengaged from the parietes towards the median line, as far as the vertebral column, and retained by a retractor. The third intercostal nerve is followed medially until the third thoracic sympathetic ganglion is reached, and that ganglion is detached from the nerve by division of its rami communicantes. The paravertebral chain is followed cranially and detached from the second thoracic sympathetic ganglion The chain is then divided caudal to the third thoracic ganglion, and its cranial end is sutured to the muscles in the upper part of the wound, in order to prevent regeneration As a further precaution the second and third thoracic nerves are divided, and their central ends are gently drawn and teased out of the intervertebral foramina, until they can be severed proximal to their posterior root ganglia After all bleeding-points have been secured, the wound is closed in layers without drainage. The opposite limb may be denervated, if this is indicated, after an interval of seven days.

Lower Limb.—This is accomplished by removal of the first, second, and third lumbar ganglia and the intervening chain Spinal

exposure and elevated caudally, the rami communicantes of the chain being divided as they are encountered. When these strands and the lesser and lowest splanchnic nerves arising from the lowest part of the thoracic chain have been isolated, the upper part of the dissection is complete. The peritoneum and the kidney in its fascia are then displaced medially and caudally, to display (*a*) the lumbar sympathetic chain, and (*b*) the splanchnic nerves piercing the crus of the diaphragm, the greater splanchnic to join the coeliac ganglion. The greater splanchnic nerve is divided at its junction with the coeliac ganglion, and the lesser and lowest splanchnic nerves are divided; the lumbar chain is divided caudal to the second lumbar ganglion. The dissection returns to the thorax; the nerve strands, now freed from all connexions, are withdrawn. The abdominal muscles are closed in one layer; the lung is inflated and the intercostal muscles sutured, care being taken to include the attachment of the diaphragm in this tier. The skin is closed. A similar operation is performed on the opposite side in seven to ten days.

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common iliac vein and on the right by the common iliac artery. The tissues in this area are carefully assembled on a blunt hook; when they have been freed for a vertical distance of 5 cm. (2 in.), a ligature is applied to their cranial and caudal ends, and the intervening segment of tissue is excised. The incision in the posterior peritoneum is closed by an inverting stitch, and the abdominal wound is closed in layers. The reproductive function is not affected.

Sympathectomy for Megacolon.—Early cases of megacolon may be treated, with reasonable hope of success, by bilateral removal of the first to fourth lumbar ganglia, inclusive, with the intervening chain. This 'sympathectomy' interrupts inhibitory fibres to the musculature of the colon, and motor fibres to the internal anal sphincter. It is not recommended after childhood; if conservative measures fail, colectomy in stages is indicated.

Splanchnicectomy and Sympathectomy for Hypertension.—In certain cases of hypertension, while the blood-pressure is labile and in the absence of gross organic changes, removal of the thoracic splanchnic nerves, the caudal part of the thoracic sympathetic chain, and the cranial part of the lumbar sympathetic chain is followed in a small proportion of favourable cases by a permanent fall in blood-pressure, and in a much higher percentage of cases, by symptomatic relief from headache and other symptoms. This extensive operation has the following physiological effects (*a*) removal of vasoconstrictor tonus from the splanchnic vessels (greater splanchnic nerve), the renal vessels (lesser and lowest splanchnic nerves), and the vessels of the lower limbs (lumbar chain), and (*b*) interruption of the nerve pedicle of the adrenal gland (lowest splanchnic nerve). To be effective, the procedure must be bilateral.

Technique—Intratracheal anaesthesia is employed; the patient is placed in the 'kidney' position To expose the extensive field of operation we employ the following dissection. An incision is made in the line of the eleventh rib, from its junction with the lateral border of the sacrospinalis muscle to the lateral border of the rectus muscle. The rib is resected subperiosteally, and the flat muscles of the abdomen are separated or divided to the level of the peritoneum the diaphragm is separated from its attachment to the eleventh rib The edges of the wound are held apart by a self-retaining retractor The pleura is then gently separated from the parietes and from the superior aspect of the diaphragm, in a medial and cranial direction, until the thoracic sympathetic chain (laterally) and the greater splanchnic nerve (medially) are displayed Usually the upper limit of exposure of the chain is the eighth or ninth thoracic ganglion, the greater splanchnic nerve may be followed to a higher level Chain and splanchnic nerve are divided or avulsed at the upper limit of the

Axillary Glands

Anatomy.—The lymph glands of the axilla are arbitrarily divided into groups according to their anatomical position. A *central* group, which lies embedded in the axillary fascia and fat in the neighbourhood of the intercosto-brachial nerve, receives afferents from the other groups. A *lateral* group lies in the line of the axillary vessels, medial to the vein, and receives most of the lymph from the upper extremity. A *subscapular* group lies alongside the subscapular vessels on the posterior wall of the axilla, and receives lymph from the lateral and posterior part of the trunk above the level of the umbilicus. Several groups lie in relation to the pectoral muscles: the *pectoral* glands, lying along the lower border of the pectoralis major between the third and sixth intercostal spaces, drain the lateral two-thirds of the mammary gland and the anterior abdominal wall above the umbilicus. The *subpectoral* glands lie underneath the pectoralis minor, and receive lymph from the lateral wall of the thorax. There are sometimes a few glands between the pectoral muscles (*interpectoral*). The *apical* group lies at the apex of the axilla on the medial side of the axillary vessels on the first digitation of the serratus anterior. One of the glands may be in front of the axillary vein. These glands receive lymph directly from the mammary gland as well as the efferent vessels from the lower groups.

Removal of the axillary glands is indicated in melanoma of the upper extremity. The arm being abducted to a right angle and supported, an incision is made across the space, over the most prominent part of the swelling, and extending well over the pectoralis major in front and the serratus and latissimus dorsi posteriorly. The glands are then removed by dissection, but it is recommended to commence by dividing the fascia over the pectoral in front and the serratus and latissimus behind, clearly demonstrating the boundaries of the space, and then to proceed to clear the axilla, preferably beginning from the lateral wall where the vessels and nerves lie, and working towards the thoracic side.

Lymph Glands of Head and Neck

Anatomy.—The lymph glands of the head and neck are numerous and their arrangement somewhat complicated. It is convenient to regard them as consisting of a main chain (deep cervical) in the line of the internal jugular vein and a 'collar' chain made up of small groups at the junction between the head and the neck; in addition, there are a few glands at the middle line of the neck.

The *deep cervical* glands extend along the whole length of the internal jugular vein. They are mostly hidden by the sternomastoid muscle, but some appear at its posterior border. Special names are given to the more important members of this group. The *jugulo-digastric* or 'tonsillar' gland lies below the posterior belly of the digastric in the angle between the common facial and the internal jugular veins. It is specially concerned in the lymph drainage of the tongue and the tonsil and is the usual starting-point for tuberculous disease of the cervical lymph glands The *retro-pharyngeal* glands lie deeply behind the lateral border of the naso-pharynx. The *supra-clavicular* glands extend laterally into the posterior triangle and are embedded in the fatty tissue superficial to the brachial plexus. They are in communication with the apical group of

CHAPTER IV

OPERATIONS ON LYMPH GLANDS

Inguinal Glands, Axillary Glands, Cervical Glands

Inguinal Glands

Anatomy.—The glands in the groin are arranged in two groups—superficial and deep. The *superficial inguinal glands* consist of: (1) a *proximal group* which forms an oblique chain lying immediately below the line of the inguinal ligament from the anterior superior spine to the pubic tubercle, a few of its members sometimes lying above the line of the inguinal ligament They receive lymph from the lower part of the anterior abdominal wall, from the buttock and lateral part of the thigh; the medial members receive lymph from the anal canal, the perineum, and the external genitals, and are frequently infected in malignant disease in these areas and in venereal disease. (2) A *distal group* which lies alongside the upper end of the long saphenous vein, and receives lymph from the superficial tissues of the greater part of the lower extremity. These are liable to be infected in septic conditions and in superficial malignant disease, such as melanoma or squamous epithelioma.

In the treatment of melanoma, which is frequently met with about the matrix of the great toe or in the sole of the foot, the removal *en bloc* of the lymph glands in the groin, both vertical and horizontal chains, along with the surrounding cellular tissue, is an essential part of the operation An oblique incision parallel to, and a little below, the inguinal ligament is made through the skin, and the two flaps are reflected as far as possible. The incision is then carried down to the deep fascia completely around the area exposed. The superficial fascia and lymph glands are dissected from the periphery towards the centre. The dissection commences above, where the fascia is readily stripped from the surface of the external oblique aponeurosis; as it proceeds, three small branches of the femoral artery—the superficial circumflex iliac, the superficial epigastric, and the external pudendal are secured and ligated. The long saphenous vein is divided at the lower limit of the dissection. The concluding steps consist in the separation of the fat and glands in the region of the saphenous opening. At this point the saphenous vein is divided again, immediately before it enters the femoral vein, and care must be taken at this stage not to injure the femoral vein. The operation is completed by inserting a drain through a small stab wound in the lower flap and closing the main wound There is a profuse discharge of lymph from the divided lymph vessels for the first few days after operation.

Axillary Glands

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axillary glands and receive a few lymph vessels from the upper part of the breast.

the hyoid bone. The first three groups drain the scalp and face, while the submandibular and submental glands receive lymph from the tongue and mouth as well as from the superficial tissues. The *superficial cervical* glands are a downward extension of the parotid group along the upper part of the external jugular vein.

Operation for Tuberculous Cervical Glands.—The only satisfactory type of operation, irrespective of the stage of the disease, is a complete removal of the affected glands. In a large proportion of cases the disease commences in the 'tonsillar' or jugulo-digastric gland and involves the upper members of the deep cervical group. The operation for disease in this situation will be considered in the first instance.

A small sand-bag is placed underneath the neck, the face is turned to the opposite side, and the chin tilted upwards. The incision should be placed in the line of the skin folds, and it is often possible to place it in a natural crease so that the resulting scar is almost invisible. Scratch marks should be made with a fine needle on the skin across the line of the incision so as to facilitate exact apposition of the skin edges at the end of the operation The length of the incision depends on the size of the glandular swelling, if only a few glands are involved, it extends from a point a finger's breadth from the middle line to the posterior border of the sternomastoid, in more extensive cases it extends from the middle line of the neck to the anterior border of the trapezius In the earlier part of the operation care must be taken to avoid injury to the cervical branch of the facial nerve. This twig emerges from the lower end of the parotid gland and runs forwards close to the angle of the jaw to supply the muscles of the lower lip as well as the platysma. If it is divided, the lip is partly paralysed and an unsightly deformity of the mouth results, which may be permanent The nerve is avoided if the incision is carried through the platysma and the further dissection carried out under this muscular layer The flaps of skin and platysma are dissected well up and down. The external jugular vein and the great auricular nerve are seen running vertically on the surface of the sternomastoid The anterior border of the sternomastoid is freed from the deep fascia and drawn backwards, exposing the group of enlarged glands It is often advisable to commence the mobilization of the glands in front, where they are clear of

the great vessels. By working down to the lower end of the group of glands the internal jugular vein can be exposed, and it forms the key to the further dissection. The glands are dissected from below upwards from the vein. It may be necessary to ligate the common facial vein in order to free the tonsillar gland from its position between the common facial and the internal jugular vein. As the dissection proceeds upwards, it approaches the angle between the posterior belly of the digastric and the sternomastoid. In this region the accessory nerve, accompanied by the superior sternomastoid branch of the occipital artery, must be identified and avoided. It enters the deep surface of the sternomastoid 2·5 cm. (1 in.) or more below the tip of the mastoid process. The hypoglossal nerve is commonly seen as it curves forwards superficial to the external carotid artery immediately below the digastric. When the glands have been freed from the great vessels and the neighbouring structures, the remaining adhesions are divided and the glands removed. If the posterior members of the upper deep cervical glands are involved, they can usually be exposed and removed after the sternomastoid has been freely mobilized and drawn backwards. In exceptional cases, when the diseased glands extend into the posterior triangle, it may be necessary to free the posterior border of the sternomastoid and retract the muscle forward; if the latter method is employed the greatest care must be exercised to avoid injury to the accessory nerve where it emerges from the sternomastoid, as it is almost subcutaneous in position and may lie on the surface of the glandular swelling.

The operation is completed by making a small stab in the lower skin-flap and inserting a drain of rubber tissue. The platysma is sutured with catgut and the skin closed with clips, supplemented by two or three sutures of fine silkworm gut. The clips and the drain are removed on the third day and the sutures a few days later.

When the glandular swelling is situated in other positions in the neck, it is dealt with by an operation on similar lines. If the submandibular group is infected, it will usually be necessary to remove the submandibular salivary gland as well

Operation for Removal of Malignant Glands in the Neck by Butlin's Method.—Malignant disease of the cervical glands is usually treated by some form of radiation. In exceptional cases, especially where the glands are too large for radiation to be likely to succeed, operative removal may be called for. The structures on the side of the neck to be operated upon are put on the stretch by raising

…, from the tip of the mastoid process to the sternoclavicular joint, and from a point opposite the level of the upper border of

the thyroid cartilage a second incision is carried upwards and forwards to the symphysis menti. These incisions go through the skin and platysma, the external jugular vein and the great auricular nerve being saved if possible, and the integumentary flaps thus delimited are reflected until the whole of the cervical fascia covering the anterior triangle is exposed. The anterior edge of the sternomastoid having been defined from below upwards, the muscle is drawn back with a broad retractor and the dissection continued until the carotid sheath is exposed. The cellular tissue, which contains the cervical lymph glands, is then dissected from below upwards in one piece, exposing the great vessels in their entire length. The depressor muscles of the hyoid are cleared, and all processes of fascia and fat passing between them and around the vessels are removed. The descending branch of the hypoglossus nerve should be avoided. When the upper end of the carotid sheath is reached, the mass of mobilized connective tissue and lymph glands is left attached at the lower end of the parotid gland and the dissection recommenced in front. The submental glands and connective tissue are dissected from the surface of the mylohyoid muscle. The submandibular salivary gland is freed from the lower border of the mandible and the facial artery and anterior facial vein are secured at the anterior border of the masseter muscle The submandibular salivary and lymph glands are then dissected from the digastric triangle. The duct of the salivary gland is divided where it disappears under cover of the posterior border of the mylohyoid The hypoglossal nerve must be avoided as it lies on the floor of the triangle on the surface of the hyoglossus muscle. As the posterior extremity of the salivary gland is freed, the facial artery is secured and divided at the point where it reaches the lower border of the gland The dissection now reaches the lower end of the parotid gland where the earlier dissection was stopped. The lower end of the parotid gland is removed, the internal jugular vein cleared to its upper end, and the entire portion of mobilized connective tissue, with the lymph and salivary glands, removed in one piece Sometimes the glands are so firmly adherent to the internal jugular vein that it is necessary to remove a segment of this vessel, the vein being first secured by passing ligatures round it with an aneurysm needle. It may even be necessary to excise a portion of the external carotid artery above the origin of its superior thyroid branch.

After all haemorrhage has been arrested, the cut surface of the parotid gland should be sutured with catgut before the skin flaps are replaced and stitched in position A long narrow drainage tube is inserted at the lower angle of the wound and left in position for forty-eight hours. A considerable quantity of saliva sometimes

escapes from the cut surface of the parotid, but there is no fear of a permanent salivary fistula.

If the glands on the opposite side of the neck are implicated, a similar operation should be carried out on that side after an interval of a week or ten days.

Operation by the Method of Crile.—A more extensive dissection, including removal of the sternomastoid muscle and the internal

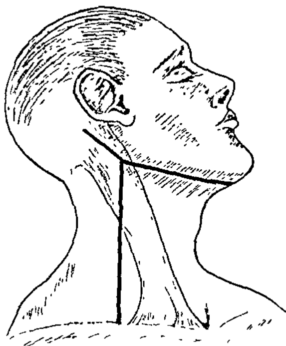


FIG. 31 Incision for Removal of Malignant Cervical Glands by the Method of Crile.

jugular vein, may be carried out in the more advanced cases of malignant disease. The incision begins below and behind the mastoid process and curves downwards and then forwards parallel to the border of the mandible to reach the middle line a short distance below the chin. Another incision begins at the junction of the posterior and middle thirds of the first incision and is carried downwards over the sternomastoid muscle to the upper border of the clavicle (Fig 31). The three flaps of skin and platysma are dissected widely and the whole of the side of the neck exposed. A director is passed under the sternomastoid and the muscle divided immediately above the clavicle. The anterior and external jugular veins are ligated and divided in this region. The internal jugular vein is freed from the common carotid artery and the vagus nerve and divided

immediately above the clavicle. To guard against the risk of bleeding from the distal end, two ligatures should be placed on the vein about 1 cm. (¼ in) apart, and the vein divided between the upper ligature and another ligature or clamp; the lower end is left secured by two ligatures. The connective tissue, lymph glands, sternomastoid muscle, and the internal jugular vein are then dissected up in one mass. As the dissection proceeds, the common, external, and internal carotid arteries, the vagus, phrenic, and hypoglossal nerves, and the muscles of the anterior and posterior triangles are exposed. The accessory nerve is usually divided at the point where it enters and leaves the sternomastoid muscle, but it may be possible to free the nerve from the muscle and preserve it The submental and submandibular regions are dissected from before backwards in the manner already described The sternomastoid is divided immediately below its insertion and dissected downwards until the upper end of the internal jugular vein is exposed. The vein is distended with blood owing to its having been ligated below It is isolated from the vagus nerve and internal carotid artery and secured by a double ligature in the same way as at the lower end. The remaining connexions of the mass of mobilized tissue are divided. A drainage tube is inserted through a stab in the lower part of the posterior flap and the wound closed.

The amount of exposure that is gained by removal of the internal jugular vein is not very great, and if the glands are not adherent to the vein, it may simplify the operation considerably to leave the vein behind. In bilateral dissections the vein should not be ligated on both sides.

W. Q W.

CHAPTER V

OPERATIONS ON BONES

Simple Fractures. Compound Fractures Mal-union and Delayed Union. Operations for Individual Fractures. Operations for Disease: Osteomyelitis. Tumours.

Operative Treatment of Fractures

Operations on Simple Fractures.—The procedure consists in exposing the fragments and fitting them accurately together; usually there is added some mechanical device for fixing the fragments after they have been fitted. By this means more accurate alinement of the fragments is obtained than is possible by any other method, but opinion is not unanimous that so accurate alinement is necessary in all cases.

Although the necessity of treating old mal-united or un-united fractures by operation has long been recognized, its use in recent fractures is comparatively modern. Operation is indicated when there is wide separation of the fragments, when the deformity cannot be overcome by other means, and when there is reason to suppose that soft parts are interposed between the fragments. Many other fractures, which were formerly treated by conservative methods, are now operated upon with excellent results, but before this method is used the dangers inherent in open treatment must be fully recognized. The operation may be difficult and there is a risk of infection, especially when a foreign body used as a fixing agent is left in the wound. The introduction of chemotherapy has to some extent reduced the risks of infection, but its use does not justify any relaxation in the observance of the most stringent aseptic technique in operations on bones.

From the standpoint of treatment, fractures may be divided into different groups: (1) a group comprising the majority of fractures in which operative treatment is unnecessary; (2) a small group with wide separation of fragments, with irreducible displacement, or with tissue interposed between the bones, in which only the open method can secure a satisfactory result; and (3) a debatable group in which the surgeon's decision to operate depends on whether he believes that a more satisfactory result can be obtained by operation than by non-operative means. It should be emphasized that open reduction, even when combined with firm internal fixation, comprises only one step in treatment, success or failure depends upon after-care. Adequate splinting, and all forms of treatment designed to restore good

function, are as indispensable for a satisfactory result as in fractures treated by non-operative methods.

Before operation is decided upon, the position of the fragments should be determined by stereoscopic radiographs, or radiographs taken in two planes. These should be repeated within a few days of the operation. The most favourable time for operation is usually towards the end of the first week, when the tissues have recovered vitality; if it is delayed longer the muscles become hard and inelastic, and the correction of displacement correspondingly more difficult. Simplification of operative technique is desirable, and it should be the aim to dispense entirely with internal fixation, to limit the operation to open reduction alone, whenever this is possible, and to maintain alinement by external splinting. In some cases, however, internal fixation is required; for these the problem has been simplified by the introduction of screws, plates, and wire of metal alloys (vitallium), and of certain forms of stainless steel which are not injurious to the tissues. As a rule it is advisable to remove the fixing agent when union has been obtained, often this can be done under local anaesthesia.

Conduct of an Open Operation —The skin purification consists of a forty-eight-hour pre-operative preparation of the whole limb by one of the recognized methods. At operation the prepared limb is covered with sterile stockinette, or with towels and sheets, to permit traction and manipulation without breaking aseptic technique. Preparation for traction and counter-traction may be made conveniently on an orthopaedic table, or by means of some other screw traction apparatus; if these are not available, counter-traction can be secured in the lower limb by a folded sheet passed round the groin of the affected side and tied to the head of the table, and traction can be applied through towels looped round the ankle. In the upper limb counter-traction is secured by a broad strip passed round the thorax and fixed to the other side of the table, and traction through towels looped round the flexed elbow or wrist. As far as possible *the handling of instruments, suture material, towels, and* fixation material is done with suitable forceps. The touching with the fingers of anything pertaining to the operation should be reduced

The skin edge should be protected by fixing the cut edges of the stockinette or the towels to the edge of the wound by towel clips, or by sterile adhesive solution applied to the stockinette before the incision is made.

The bone is reached directly by separating overlying muscle and periosteum together, so that the periosteum is retracted with muscle

tissue attached. The most easily accessible fragment is then delivered into the wound by means of a bone-lever and by manipulation of the limb; the other fragment is dealt with similarly. Each fragment is then grasped with a large, long-handled, bone-holding forceps. The fragments are then bent to a sufficiently acute angle to engage the cortical parts of both (Fig. 32). Traction and pressure applied over the angle formed by the fragments aid in the final coaptation of the bone-ends. If mechanical fixation of the coapted fragments is required, in transverse fractures they are held rigidly in position by powerful screw clamps, and a plate of suitable size is applied, if possible to an aspect of the bone which is well covered by soft parts. Holes are made with a drill of slightly smaller diameter than the



Fig. 32. Plate and Screws (Sherman) applied to a Fracture. Note the position of screws which transfix both cortical layers of bone.

screws. The screws, held with special forceps, are screwed firmly home (Fig 32). At least one screw above and below the fracture line should traverse the whole width of the bone. In oblique fractures the coapted fragments are held rigidly in position; a drill rather smaller than the screws to be used is passed through the whole thickness of the bone at two or more different angles; the holes nearer the operator are slightly enlarged, and the screws are inserted. This plan ensures that when the final tightening takes place the fragments are firmly held together (Fig. 36) The wound is closed in layers. In order that blood and serum may escape, the skin sutures are not placed close to each other.

In certain circumstances the employment of wire for the fixation of fractures is advantageous. It must be malleable and strong to allow of twisting, aluminium-bronze or stainless steel wire is suitable, silver wire is not strong enough. In applying the wires a special tightening instrument may be used. After they are twisted, the ends of the wire should be bent over and hammered into the bone. The wire should be removed when callus has formed. If the bone involved can be exposed from both sides, bolts can be used with advantage, for example, in an oblique fracture of a femoral condyle with separation of the fragments.

Operations on Compound Fractures.—In cases of compound fracture, when it has been decided to attempt to save the limb, operative treatment is concerned with prevention of sepsis as well as

with alinement and fixation of the fragments. The wound is first covered with sterile gauze, the whole limb thoroughly cleansed with soap and water, and shaved; it is then painted with spirit and iodine or an antiseptic dye to diminish the risk of infecting the interior of the wound. *Toilet of the wound* is then carried out. This consists in removing a narrow strip of the skin edge, in excising devitalized tissue, and in removing all dirt and extraneous matter. If the fracture is a *comminuted one*, completely detached chips of bone should be removed, but all attached pieces should be cleansed as thoroughly as possible and retained, because they will contribute to union by being incorporated in callus.

If the patient is treated within six hours of the accident it is usually safe to close the wound after adequate toilet. A small quantity (up to 5 gm) of soluble sulphanilamide should be placed in the wound before closure. In cases treated after six hours it is better to pack the wound lightly with tulle gras or with gauze soaked in sterile liquid paraffin, and to begin sulphanilamide or penicillin treatment forthwith In fractures of small bones 500,000 units of penicillin is a sufficient total dose, but in fractures of large bones with extensive soft tissue damage 1,000,000 units or more are necessary. In the majority of cases so treated the wound can be closed by secondary suture within a few days If there is a large raw area it should be covered by the use of relief incisions, or by skin grafting.

After the toilet and reduction of a compound fracture the bones are kept in position by enclosing the limb in plaster of Paris if the fracture is transverse and shows little tendency to redisplacement; by adhesive plaster or skeletal traction if the fracture is oblique or comminuted The skeletal traction is applied to the distal extremity of the affected bone by means of a Steinmann pin, a Kirschner wire, or an ice-tong calliper The limb is supported on a splint or frame until callus has formed, usually after four or five weeks. Thereafter, if it is considered advisable, a plaster-of-Paris cast can be applied

Operations for Badly United Fractures.—Operation may be required in mal-united fractures because the fragments have united in a faulty position, or to remove excess of callus which presses on a nerve or interferes with the movement of a joint. When the fragments have united with angulation the correct alinement may be secured by reproducing the fracture and resetting The site should be explored subperiosteally, and then with a twist drill of $\frac{3}{16}$-inch diameter for a large bone or of a smaller diameter for a small bone a series of holes should be drilled through the mal-united bone. The first hole should be in a diameter of the bone subsequent holes are drilled more distally, diverging from each other towards the anterior and posterior margins of the bone, for the femur of an adult about

nine are required. At the completion of the drilling the holes should be arranged like a 'V', its apex proximal (Fig. 33). The holes in the cortex facing the operator are now joined by cuts of a thin osteotome and the anterior and posterior surfaces of the bone are similarly divided opposite the most distal holes. The cortex distal to the operator is not divided by the osteotome, but it is weakened by the drill holes, and bends or breaks when force to correct the angulation is applied to the site. Usually there is little tendency to displacement and the limb can be put up in a plaster of Paris case, or treated by traction on a splint; but if there is a tendency to re-angulation a plate should be applied.

When there is gross overriding the main fragments must be separated by an osteotome, their ends (which are closed by callus) exposed, and the medullary cavities restored. As a rule the fragments can be brought into apposition by the use of levers, by angulation, or by skeletal traction applied on the table. If this is not found possible, the wound should be closed and the patient returned to bed; strong skeletal traction for a week or more will probably restore full length. In a few cases it is necessary to lengthen tendons and to divide contracted fascial planes. When good alinement has been obtained, it can be maintained either by continued traction or by the application of screws or a plate.

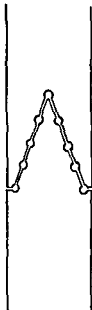


Fig. 33. Method of drilling Bone to reproduce Fracture for Resetting.

Operation for Delayed Union and Want of Union.—It is usual to consider that union is delayed if it has not been completed in five or six months, and that non-union is present if there is little or no evidence of union after six months. By radiography it is usually possible to determine whether delayed union is caused by atrophy of the bone, by sclerosis of its ends, by deficient callus formation, by want of apposition of the fragments, or by the presence of soft tissues between the fragments Drilling of the bone in the region of the fracture, as advised by Beck, is often successful when the delay is due to atrophy, sclerosis, or deficient callus formation. One or two small incisions are made near the bone-ends, and a drill of 0·3 cm. ($\frac{1}{8}$ in.) diameter is passed down to the bone proximal to the fracture site [illegible]

[illegible] procedure is then carried out through the distal fragment so that the ends of both fragments are riddled with drill holes (Fig.

34). The limb can be immobilized in plaster or treated with traction on a splint or frame The operation frequently leads to solid bony union, and if it fails it does not interfere with further open operative measures.

If operation is required in cases of delayed or non-union of fractures, the most satisfactory results are obtained by autogenous bone grafting. The fracture site is exposed by subperiosteal stripping

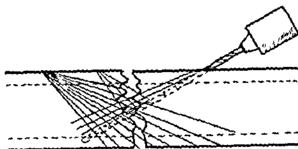


Fig 34. Method of drilling Bone for Delayed Union.

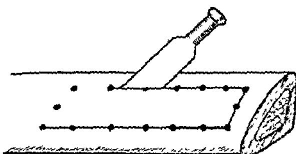


Fig 35 Method of cutting Autogenous Bone Graft from Tibia.

with a sharp instrument, so that small fragments of bone are prised off and remain adherent to the periosteum The bone-ends are separated and rawed and the medullary cavities are re-formed by drills and curettes The highest percentage of success is achieved by using autogenous massive onlay bone grafts, intramedullary and sliding grafts are not so successful When the fragments have been put in position, the outer layers of the cortex are chiselled from the surface on which the graft will rest A graft of suitable length and breadth is now removed from the anteromedial aspect of the patient's tibia by an electric saw, or by connecting drill holes with an osteotome (Fig. 35) Excess endosteal bone is removed from the deep surface of the graft which is then placed on the prepared surface, extending above and below the fracture line for a distance of 7·5 cm (3 in) It is held in position with a clamp in the same way as a metal plate

(p. 87). The graft can be fixed by autogenous bone pegs, which are cut from the tibia with an electric saw and rounded with a reamer. The pegs should pass into the medulla, or even across into the opposite cortex, and should be staggered in the direction of their passage.

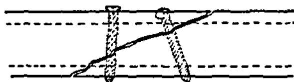


FIG. 36 Method of securing Oblique Fracture by Two Screws.

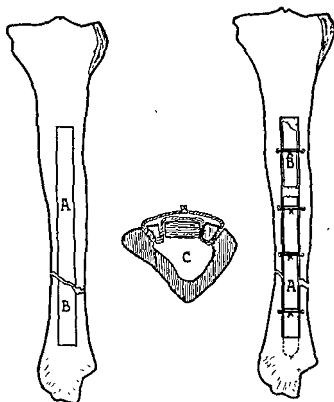


FIG. 37. Method of cutting and securing Sliding Bone Graft.

While the use of autogenous bone pegs or screws probably gives the highest percentage of solid union, and the least trouble afterwards, their making considerably increases the duration of the operation. Good results are obtained when metal screws are used to anchor autogenous bone grafts. They are applied in the same manner as in an oblique fracture, at least one screw should traverse the whole thickness of the bone (Fig 36). Occasionally the absence of mineral matter in the distal part of the bone is such that screws cannot obtain a hold

in it. In such cases a sliding graft may be used; this is cut with a double electric saw from the proximal solid fragment, firmly embedded into the distal soft fragment, and anchored to the proximal fragment, either by screws or sutures (Fig. 37). If the fragments are widely separated, or muscle or other soft tissue lies between them, the ends are defined, rawed, and brought into apposition. They are secured by plates, bone grafts, or traversing screws as may be found necessary.

After a bone graft has been secured, an attempt should be made to cover it with periosteum, even if this means making relief incisions in the periosteum where it has been stripped from the sides of the bone, and the limb should be immobilized as in a recent fracture. Weight-bearing should be allowed only when union is well advanced; a calliper splint may be used to take the strain off the site of fracture until the young callus becomes bone.

Operations for Fractures of the Lower Extremity

The Tibia and Fibula.—The approach to the *tibia* is along the subcutaneous surface of the bone, the incision may be as free as desired, and may be curved with the convexity posterior to separate the skin wound from that in the bone

In approaching the *fibula*, regard must be had to the lateral popliteal nerve. In the upper and middle thirds the incision is made in the line of the posterior intermuscular septum, in the *upper third* the wound is deepened between the soleus and peroneus longus muscles, the lateral popliteal nerve being avoided as it winds round the neck of the fibula, in the *middle third* the dissection is between peroneus longus and flexor hallucis longus In the *lower third* the incision is immediately lateral to the anterior intermuscular septum; it opens the interval between peroneus brevis and peroneus tertius

In operating for *recent fractures* of the leg, only the tibia is dealt with; fixation of the fibula is unnecessary.

Fracture of the Head of the Tibia—Usually even serious fractures from direct violence can be moulded into shape without operation, but if the condyles are widely separated operation may be necessary; this is especially true of the lateral condyle because the lateral meniscus tends to pass distally between the fragments, and must be removed before the condyle can be replaced. The approach is through a longitudinal incision extending from one or other side of the patella downwards for about 8 cm (3 in) below the knee-joint. When replacement has been achieved, the condyle is anchored by criss-cross autogenous grafts taken from the same tibia, by beef-bone pegs, or by wire which traverses both condyles and passes round their anterior aspects. If wire is used, a small incision is required

over the unaffected condyle, to receive one end of the wire and enable it to be passed round in front.

Fracture of the Tubercle of the Tibia, or *Separation of the Tongue-like Process of the Upper Epiphysis.*—When there is displacement that is not corrected by relaxation of the quadriceps, the tubercle may be exposed by a medial incision and the fragment anchored with a beef-bone peg, or by suture of the torn periosteum.

Patella.—Transverse fracture of the patella implies a rupture of the extensor apparatus of the knee, and in its repair suture of the torn extension at the sides and in front of the bone is of paramount importance. The best approach is through a horizontal incision at the level of the tear The fragments are drawn apart with sharp hooks, and all blood and serum are washed out of the joint cavity with saline solution, or mopped out with moist gauze. The fibrinous blood-clot which adheres to the rough surface of the fragments is removed with moist gauze, and any shreds of the aponeurosis between the fractured surfaces are raised so that they may not become interposed when the fragments are approximated. The fragments are fitted accurately together, and sutured with strong chromic catgut. Two vertical sutures, or one transverse suture, may be used, the catgut being threaded through drill holes, which should avoid the articular surface (Fig. 38) After the bone has been sutured, the torn lateral extension on each side should be firmly repaired, and the aponeurosis in front of the fragments should also be approximated. The leg is put up in a plaster-of-Paris case extending from the groin to the ankle, and the patient is nursed with the hip flexed to relax the rectus femoris muscle. Quadriceps exercises are carried out from a few days after operation. In fourteen days the stitches may be removed, the plaster changed, and the patient allowed to walk. The plaster case should be retained for six weeks, when active physiotherapy should be started.

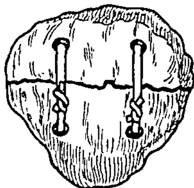


Fig. 38. Method of securing Transverse Fracture of Patella.

An alternative method is to excise the patellar fragments by shelling them out from the extensor apparatus. The ruptured extension is then sutured firmly with slight overlapping. Active movement, without weight-bearing, may be started a few days after the operation, and a satisfactory range of movement is usually obtained by the end of the sixth week. This procedure shortens

in it. In such cases a sliding graft may be used; this is cut with a double electric saw from the proximal solid fragment, firmly embedded into the distal soft fragment, and anchored to the proximal fragment, either by screws or sutures (Fig 37). If the fragments are widely separated, or muscle or other soft tissue lies between them, the ends are defined, rawed, and brought into apposition. They are secured by plates, bone grafts, or traversing screws as may be found necessary.

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the rectus femoris and vastus lateralis or medialis muscles. The periosteal cuff must be incised, after which it is possible to replace the epiphysis by leverage. To prevent re-displacement, two excision pins should be driven up criss-cross, through the condyles into the diaphysis. The limb should be put up in a plaster-of-Paris spica with windows over the excision pins, which can be withdrawn in fourteen days.

Fracture of the Neck of the Femur.—The original operation of Smith-Petersen consisted in reducing an intracapsular fracture of the neck of the femur by open operation, and in securing the fracture by means of a three-flanged stainless steel nail driven up the femoral neck into the head. The open operation has been replaced by extra-articular insertion of the nail. The patient is placed on an orthopaedic table, and the fracture is reduced by combined traction and internal rotation with the thigh flexed to a right angle. When reduction has been achieved, the feet are fastened to the foot-pieces with sufficient traction to prevent displacement, and so far apart that the line joining them forms an equilateral triangle with the legs. The affected hip is fixed in 15° internal rotation. The guide-pin is now passed through the soft tissue to the outer side of the femur, about 1 cm. (½ in.) below the upper border of the greater trochanter. The level can be ascertained by palpating the greater trochanter, and the centre of the shaft appreciated by passing the pin in front of and behind the bone. The guide-pin is screwed in the direction of the opposite anterior superior iliac spine. The depth to which the guide must be introduced can be gauged by placing another guide-pin of equal length on the surface, parallel to the pin that has been introduced; but usually it is quite easy to appreciate by touch when the point is passing through the fracture line and into the femoral head. Radiographs in two planes are now taken. The radiographs usually show that the axis of the guide-pin is correct, although the insertion may be too low, too high, too far forwards, or too far backwards. An incision is now made 3·5 cm. (1½ in.) in length along the line of the guide-pin, and the periosteum is stripped off the femur. If a new pin must be inserted parallel to the first one, this can be done by utilizing metal blocks with parallel holes drilled at varying distances. An appropriate block is selected, one hole is threaded over the first guide-pin, and the second guide-pin is threaded through the second hole and inserted to the desired level (Fig. 39 D). The first pin is now withdrawn and new radiographs are taken. If the first guide-pin is in the wrong axis, then an angle-correcting instrument, such as that introduced by Engel-May, is used to correct the angle. The length of nail required can be gauged by measuring the length of the guide-pin protruding from the cortex, and

convalescence considerably; the knee is good for most purposes, unless direct pressure is applied to it.

Stellate fracture of the patella is due to direct violence. Since the extension is not torn there is little separation, but there may be some tilting of the comminuted fragments. The swollen knee should be aspirated, and the fragments replaced by pressing the patella back against the femoral condyles. If successful replacement is obtained, the knee should be immobilized in a plaster case for six weeks. If the replacement is unsuccessful, the patella should be excised. Attempts to obtain replacement by operation and by passing a circumferential suture round the fragments are usually only partly successful; osteoarthritis is apt to develop, for which the patella must be excised at a later date

In *fractures of long standing* the bone surfaces must be refreshed by means of a saw or chisel, and all adhesions are separated before the fragments are approximated If the separation is great, considerable difficulty may be experienced in stretching the contracted quadriceps sufficiently to allow the upper fragment to be brought distally. Traction on a pin passed through the upper fragment usually succeeds, but if apposition is impossible the fragments should be excised and the gap filled with fascia lata strips drawn as tightly as possible, or by a flap turned down from the aponeurosis of the rectus femoris muscle and sutured to the patellar tendon. After three weeks active stretching of the quadriceps can be commenced. When the upper fragment has become adherent to the femur the patella should be excised and the extensor apparatus reconstructed.

Excision is applicable to all types of fracture of the patella in old patients, and to fractures in young patients when osteoarthritis is present at the time of fracture

Femur.—*Separation of the lower femoral epiphysis* is likely to be attended by gross displacement and when compound is liable to be complicated by infection of the knee-joint When displacement cannot be corrected by manipulation and flexion of the joint under anaesthesia, a Kirschner wire or a Steinmann pin should be passed [illegible]

[illegible]

right angle, and the leg suspended from the beam by a broad sling. Almost complete replacement usually takes place within two days; the reduction should be completed, the wire or pin removed, and a [illegible]

[illegible]

the fragments Operation is then indicated. The approach is between

be encouraged to keep the leg in slight internal rotation while it is at rest. Movement of the knee should begin on the first day, and [illegible] The patient is allowed almost [illegible] to bear [illegible] vertical, a longer time should be allowed to elapse than if the fracture is more horizontal. Important points in the operation are: (*a*) the reduction should be carried out gently to prevent tearing of possibly displaced

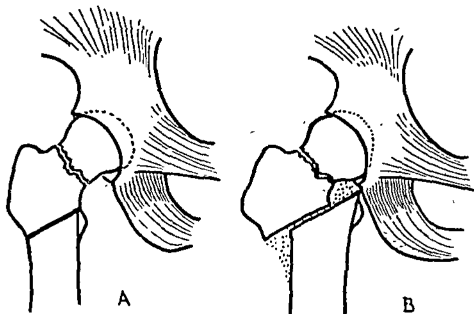


Fig. 40. Steps in MacMurray's Operation for Non-union of Fracture of the Femoral-Neck.

but intact parts of the retinacula; (*b*) as few guide-pins as possible should be used, and they should not approach nearer than 1 cm. (½ in.) from the articular surface of the head lest they damage essential blood-vessels entering through the ligamentum teres; (*c*) the nail point should not approach nearer than 0·5 cm. (¼ in.) from the articular surface of the femoral head; and (*d*) traction should be relaxed while the nail is being introduced.

About 80 per cent. of cases of fracture of the neck of the femur treated by nailing obtain solid union; but owing to deficiencies in the blood-supply, or other causes, the remainder fail to unite.

One treatment for *non-union in fractures of the femoral neck* is the oblique osteotomy described by MacMurray. A 12·5-cm. (5-in.) incision is made on the lateral aspect of the upper end of the femur, commencing above the greater trochanter and extending vertically

subtracting that from the total length of the pin An examination of the radiograph will show whether the nail must be inserted farther than the guide-pin or less far The nail is now threaded over the correctly placed guide-pin (Fig. 39 F) and hammered home until the lower border of its head is tightly against the cortex of the femur. While

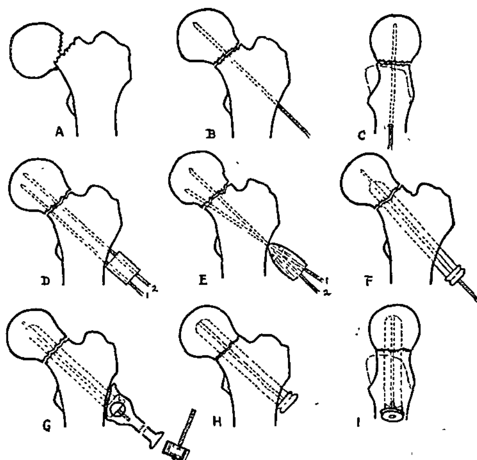


FIG. 39 Steps in the Insertion of Smith-Petersen Pin.

this is being done, the opposite side of the pelvis should be supported by an assistant, and traction on the limb reduced, because if too much traction is exercised the femoral head is apt to turn when the nail point begins to enter it Slight impaction is now secured at the fracture line by hammer-blows on a Smith-Petersen impactor, which

wound is closed in layers, and the patient returned to bed. He should

lies beside the neck of the bone. It can be pushed directly back into its normal position. In fracture of the head of the radius in adults if there is a small displaced marginal fragment it may be removed, but if the head is seriously damaged the neck of the bone should be divided and the whole head removed. The wound is then closed in layers. Operation should be carried out from eight to ten days after the accident.

Fracture of the Olecranon.—Fracture of the olecranon process of the ulna with marked separation of the fragments requires operation in from seven to ten days. The fracture is exposed by an incision, commencing 3·5 cm. (1½ in.) above the olecranon, and carried distally in a straight line along the lateral border of the olecranon and ulna. Blood-clot is removed from the joint and the fragments are fitted together and held in position with towel clips. A transverse drill hole is made through the proximal end of the distal fragment and a stout chromic catgut thread is passed through this. The catgut is made to cross over the superficial aspect of the fracture line and to pass through the most distal part of the triceps tendon. When this suture is tightened, the fragments are held closely together and show no tendency to angulation. The torn lateral expansion is sutured on both sides of the fracture. If the fracture through the olecranon is more anterior, drill holes should be made through both fragments, and they should be lashed together with stout catgut, the lateral extension being repaired as before. After closure of the wound the arm should be put up in plaster with the elbow at right angles and the forearm in mid-position for fourteen days, when active exercises should begin.

An alternative method is to excise the smaller fragment. The bone is peeled out from the triceps extension, which is accurately and securely fastened to the proximal part of the ulna. In certain cases it may be necessary to utilize fascial strips, or strips turned down from the triceps aponeurosis, to ensure firm attachment of the triceps to the ulna. Excision should not be practised if the fracture line is more anterior than the midline of the sigmoid notch of the ulna, otherwise anterior dislocation of the elbow is liable to take place.

Intra-articular Displacement of the Medial Humeral Epicondyle.—Separation of the epiphysis of the medial epicondyle of the humerus by violent abduction is not uncommon in children. The separated epiphysis, with the ulnar collateral ligament attached to it, frequently slips into the interior of the elbow-joint and is trapped there. Vigorous manipulation is contra-indicated, as it is apt to damage the joint surfaces. Occasionally the epicondyle may be replaced by abducting the elbow and applying a strong faradic current to the flexor muscle in the forearm. The contraction thus evoked may pull

along the shaft. The muscular attachments in front are detached, so that the head of the femur and the acetabular edge can be defined. The line of division of the bone passes upwards and medially towards the lower border of the acetabulum. The lesser trochanter is usually, though not always, distal to the osteotomy. The shaft of the femur is displaced medially until its upper end reaches the lower margin of the acetabulum. With a gouge the lateral surface of the femur is roughened for 8 cm (3 in.) distal to the osteotomy. The wound is closed in layers. The hip, thigh, and leg are enclosed in a straight plaster-of-Paris spica, which should be left undisturbed for at least three months. Solid union between the fragments usually results, and not infrequently the original fracture also unites. After the operation a weight-bearing apparatus is not necessary.

Operations for Fractures of the Upper Extremity

Radius and Ulna.—The whole length of the *radius* and the interosseous membrane may be safely exposed by an incision between the brachio-radialis and flexor muscles, as this is the frontier line between the radial vessels and nerve on the lateral side and the anterior interosseous vessels and nerve on the medial side. In dissecting between brachio-radialis and flexors it is a good plan to free the radial nerve on its lateral aspect, so that it may be retracted medially with the radial vessels. In the lower third of the forearm the radial nerve is to the lateral side of the incision because at this level it has left the artery to pass to the dorsum of the hand.

Incisions on the extensor aspect of the forearm, the muscles of which are supplied by the posterior interosseous nerve, may be made along the whole length of the ulna, as the dorsal branch of the ulnar nerve passes beneath flexor carpi ulnaris close to the lower end of the bone. Moreover, this incision is along the radial border of the extensor carpi ulnaris muscle, which receives its nerve supply at a higher level. The ulna is subcutaneous over the whole length of the forearm, in the interval between the flexor and the extensor carpi ulnaris muscles.

Excision of the Head of the Radius.—Exposure of the head of the radius may be required for open reduction of greenstick fracture of the neck, or for removal of a portion, or of the whole of the head of the bone. The incision commences at the lateral epicondyle and follows the lateral border of the anconeus The capsule over the head of the radius is divided sufficiently to gain access, the exposure being limited distally by the presence of the posterior interosseous nerve in the supinator muscle Unless the head is to be removed, it is wise to avoid complete division of the annular ligament, if possible In a greenstick fracture of the neck, the head is tilted laterally and often

difficult, and some such procedure as that devised by McBurney may be necessary; a hole is bored in the small upper fragment, a hook with a long handle, like a button-hook, is driven in with some degree of force and used as a lever. In fracture-dislocations the object is to replace the head of the bone in the glenoid fossa; after replacement

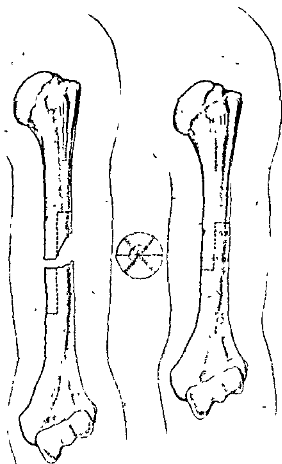


FIG 41 Step-cut Operation for Fracture of the Shaft of the Humerus.

of the head the greater tuberosity may be anchored with a small bone peg Fixation of the main fragments is not usually necessary. After operation, treatment should proceed as for uncomplicated fracture of the neck of the humerus.

In *old-standing cases of dislocation* complicated by fracture of the surgical neck in which reduction is found to be impossible, it may be wise to remove the head of the bone and interpose a layer of fascia between the upper end of the shaft and the glenoid cavity.

In *separation and displacement of the upper epiphysis of the humerus* in children, open operation usually permits accurate reduction, and

the epicondyle out of the joint; but if the epicondyle is then found to be markedly displaced, operation should be carried out to replace it. If the faradic stimulation fails to move the epicondyle from the joint operation must be carried out. The incision passes from the lower extremity of the medial epicondylar ridge distally and slightly forwards over the origin of the flexor muscles Care must be taken to avoid the ulnar nerve, which may be exposed behind the epicondylar epiphyseal bed, and, if necessary, can be isolated and retracted. After blood-clot is wiped away, a small raw bony surface is seen at the tip of the epicondyle and a strand of muscle-fibres belonging to the common flexor origin turning into the interior of the joint instead of passing to the epicondyle. A blunt hook is slipped round this mass of muscle If the extended joint be now abducted, a sharp pull upon the hook will bring the separated epicondyle out of the joint complete with its muscular and ligamentous attachments. The fragment of bone may then be fastened back in its normal position by a few sutures or by a bone peg.

Supracondylar Fractures of the Humerus.—It sometimes happens that a supracondylar fracture, especially of the T-shaped variety, resists all attempts at closed reduction Access to the distal end of the humerus may be gained by a median posterior incision which splits the lower portion of the triceps, and leads directly to the fracture.

Humerus.—In *fractures of the shaft of the humerus* open operation is most often required after severe forms of direct violence, when the fracture is comminuted and complicated by bruising or division of the radial nerve. The bone is exposed through the appropriate muscular interspace, and on the lateral aspect it is best to expose and isolate the radial nerve and profunda vessels at an early stage of the dissection. The operation includes fixation of the fragments by means of plates or screws, and suture of the nerve (p. 65).

In *un-united fractures of the shaft of the humerus* the bone-ends are usually sclerosed; they must be rawed and the medullary cavity restored; as a rule, a massive bone graft is satisfactory. Occasionally the distal end of the bone is so atrophied that screws and pins will not hold, and to secure good bony apposition step-cutting of the fragments should be carried out. The step-cuts are fitted together and held in position by wire looped round the bone (Fig. 41). After closure a plaster-of-Paris shoulder spica is applied.

Surgical Neck.—Whether as a separate fracture or as a complication of dislocation, open operation may be required. The incision begins above and to the lateral side of the coracoid process, and extends distally in the interval between the deltoid and pectoralis major muscles. Manipulation of the small upper fragment is often

As soon as possible the infecting organism should be identified and its sensitivity to penicillin determined by culture, either of venous blood or of pus aspirated from the focus of disease; blood culture is positive in about 50 per cent. of cases. There should be no delay in commencing treatment by intramuscular injections of penicillin in large doses (e.g. 50,000 units every three hours). If the organism is found to be sensitive to penicillin, therapy is continued for at least fourteen days, though the dosage can be reduced after a few days. In the rare event of the organism being found to be relatively resistant to penicillin, the dosage of that drug should be increased to correspond with the degree of resistance, and sulphathiazole or a similar compound should also be given.

Early cases of acute osteomyelitis can be cured by penicillin without any operative measure, and in all cases it is advisable to continue injections for from twelve to twenty-four hours before surgical drainage is undertaken. Clinical evidence of a subperiosteal abscess is the definite indication for surgical intervention, but clinical diagnosis of such an abscess may be difficult, especially in bones well covered by muscles such as the neck or shaft of the femur, or the shaft of the humerus. When there is doubt about the complete resolution of inflammation, it is safe and wise to test the point by aspiration or by exposure of the focus.

Drainage by needle is indicated particularly when the focus is relatively inaccessible, as in the neck of the femur or in the acetabulum. In other cases where the abscess appears to be small and localized aspiration may be all that is needed, and it is useful in children in whom cortical bone is easily penetrated. A sternal puncture or other special needle is used, and as the affected area of bone is approached, as much as possible of any subperiosteal pus encountered is removed by aspiration. The needle is then passed through the cortical bone. If pus is found in the metaphysis or medulla, it is generally under considerable tension It may be aspirated and the needle removed, but it is probably better to effect continuous drainage for a few days (till the fluid is shown to be sterile) by leaving the needle in place, fixing it to the splint which immobilizes the limb, and connecting it to a small sterile bottle by sterile rubber tubing.

Operative exposure is preferable when the presence of a subperiosteal abscess of any considerable size is suspected, and in most cases in adults. Through a suitable skin incision the supberiosteal abscess is evacuated as completely as possible, and one or two drill holes are made through the cortical bone into the metaphysis or medulla. The important part of the procedure is the removal of all

there is rarely any tendency to re-displacement if the periosteum is accurately sutured.

Clavicle.—*Simple fracture* of the clavicle requires operative treatment only when the bone is comminuted and loose fragments are displaced and press upon the subclavian vessels or the cords of the brachial plexus, and when other methods of treatment fail to keep the fragments in apposition

An incision is made over the fracture, or at a higher level. Fragments still attached to the periosteum are moulded into position, loose fragments are removed, and the adjusted ends of the bone are fixed together by kangaroo tendon, wire, plates, or bone grafts, according to circumstances. If the main fragments lend themselves to suture, each is perforated with a drill, and the suture material is passed and securely tied The wound is closed without drainage

In *compound fractures* the opening in the skin is enlarged, the wound purified, and the bone dealt with as in simple fractures.

Dislocation of the Clavicle—If conservative means fail, open operation may be called for.

At *the sterno-clavicular end* oblique holes may be drilled into the joint through the superior surfaces of the clavicle and manubrium, and a strip of fascia lata looped through and sutured firmly over the top of the joint. The clavicle may also be fastened down to the second costal cartilage by a loop of fascia At *the acromio-clavicular end*, after replacement, the clavicle should be anchored to the coracoid process by a strip of fascia, and the clavicle and acromion fastened together by a crossed fascial suture passing through two holes drilled vertically through the clavicle, and two similar holes vertically through the acromion, both placed about 1 cm. ($\frac{1}{2}$ in) from the joint surface.

Scapula.—Fractures of the acromion or of the coracoid may require operative treatment on the same lines as fractures of the clavicle.

Operations for Disease of Bone

Acute Osteomyelitis.—The introduction of penicillin has changed both the treatment and the prognosis of this condition. The infecting organisms are, with rare exceptions, sensitive to penicillin, and its prompt administration, with rest of the part by suitable splintage, controls the infection and reduces operative intervention to a minimum. In penicillin-treated cases radical procedures such as guttering or saucerization, which were formerly considered necessary, have been shown to increase the tendency to sequestrum formation.

As soon as possible the infecting organism should be identified and its sensitivity to penicillin determined by culture, either of venous blood or of pus aspirated from the focus of disease; blood culture is positive in about 50 per cent. of cases. There should be no delay in commencing treatment by intramuscular injections of penicillin in large doses (e g. 50,000 units every three hours). If the organism is found to be sensitive to penicillin, therapy is continued for at least fourteen days, though the dosage can be reduced after a few days. In the rare event of the organism being found to be relatively resistant to penicillin, the dosage of that drug should be increased to correspond with the degree of resistance, and sulphathiazole or a similar compound should also be given.

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then be closed by suture. Under penicillin treatment re-formation of the abscess is rare, and even if it occurs it can be dealt with adequately by aspiration or by a second incision. In the rare case in which it is known that the infecting organism is resistant to penicillin, the wound should be dressed with vaseline gauze and left open, and the limb should be enclosed in plaster.

In all cases rest should be ensured for the affected limb from the commencement of treatment by immobilizing the neighbouring joints in a Thomas splint or plaster gutter Complete encasement of the limb in plaster from the first is undesirable, because it may conceal the development of a subperiosteal abscess or suppurative arthritis; it should be used, if at all, only after resolution is assured or an abscess has been drained Rest should be continued till there is radiological evidence of re-calcification of the affected bone.

Suppurative Arthritis associated with Osteomyelitis.—When there is clinical evidence that a neighbouring joint may be involved in the inflammation, as the first step in any operative measures the joint should be aspirated through healthy tissues If the fluid withdrawn looks infected, as much as possible is removed and 25,000 units of penicillin in 2 or 3 c.c. of sterile water are instilled into the joint cavity This should be repeated every second day until the joint fluid is sterile. When either the hip-joint or the knee-joint is involved, the immobilization must include traction on the limb to separate the articular surfaces of the affected joint.

Chronic Osteomyelitis.—The chronic stage of osteomyelitis is marked by the persistence of sinuses and the repeated breaking down of the wound after partial healing because of the presence of sequestra and of unobliterated cavities in the bone. If the infecting organisms are sensitive to penicillin or sulphonamides, these drugs can be used with advantage, but it is important to realize that they cannot eradicate infection in avascular tissues. They are to be used in most cases only as adjuncts to operative measures directed towards the removal of sequestra or of chronically infected scar tissue, and towards closure of such cavities.

Sequestrectomy.—A sequestrum which has separated from the surrounding bone can be recognized in a radiograph as a dark shadow surrounded by a clear space For its removal a tourniquet is applied and the affected area exposed by a suitable incision. If infected scar tissue is present in the sinus track, the incision should be designed to include removal of this relatively avascular area. The cloacal opening in the bone is enlarged, the sequestrum grasped by forceps and extracted, if possible in one piece Fresh granulations in the cavity should not be curetted

If small sequestra lie in cancellous bone, the area is exposed widely

and all diseased bone is removed together with a thin layer of the apparently healthy bone.

When it is known that the infecting organisms are sensitive to penicillin and all avascular tissues have been removed, primary closure of the wound may be justifiable provided parenteral penicillin is given for at least two weeks thereafter. Otherwise the Winnet-Orr method of treatment should be adopted: the cavity is packed with a lining of vaseline gauze filled with dry gauze, and the limb is enclosed in plaster. Chemotherapy should be continued as indicated by the sensitivity of the infecting organisms. The plaster is changed at intervals of several weeks, until granulations fill the cavity and skin grafting is possible.

Treatment of Bone Cavities.—If the cavity is fairly superficial it may be treated by the operation of *planification*. A tourniquet is applied and an incision is made to explore the affected segment of bone, any sinuses in the soft tissue being excised. Bone is gouged away above, below, and at the sides of the cavity, until this is converted into a shallow trough into which the soft tissues can fall. Care must be taken not to weaken the bone by the removal of too much of its substance, or a fracture may result, which would probably become infected. The trough is packed with sterile paraffin gauze and a plaster is applied. Skin grafting may hasten the final stage of healing.

Deep, well-like cavities should be freed from sepsis by the Winnet-Orr method and then filled by a muscle pedicle flap, or by bone chips. In the former procedure a portion of a neighbouring muscle is detached from the body of the muscle distal to the cavity, and dissected up towards its origin; the distal end of the pedicle so formed is turned into the bone cavity and anchored to its edges by a few sutures In the latter procedure, cancellous bone chips taken from the anterior part of the iliac crest of the patient are placed in the cavity, and the skin is sutured over it. To enable the cavity to be covered, undercutting of the skin may have to be carried out, and relief incisions made in distant healthy skin. The gaps left by the relief skin incisions can be closed by split-skin grafts. The limb should be immobilized until healing takes place.

Circumscribed Abscess of Bone. 'Brodie's Abscess.'—An incision is made over the site of the abscess as indicated in radiographs, and the periosteum is reflected. If the abscess cavity is small and is in cancellous bone it may be excised *en bloc*. If this is not possible, the cavity should be opened by drills and gouges and its thick walls thoroughly curetted or cut away. Primary closure of the wound may be adopted if the organism is sensitive to penicillin: otherwise the Winnet-Orr technique should be followed.

Operations for Tumours of Bones

Non-malignant Tumours.—The *ivory osteoma* arising, for example, from the facial or the cranial bones is removed by perforating the bone round the base of the growth at numerous points with a highly tempered drill, and completing the division with a chisel.

The *cancellous osteoma* is removed by dividing the neck or base of the tumour with a broad gouge, care being taken to remove the whole of the cap of cartilage which overlies the osseous growth.

The *giant-cell tumour* which usually grows at one end of a long bone is most successfully treated by deep X-ray therapy. If this fails to stop the growth of the tumour and to bring about bony repair, the tumour area with a healthy zone of bone around should be removed with gouges and curettes and the resultant cavity filled with bone chips from the iliac bones. In some cases the function of the limb is so far impaired by the local growth, or by its local removal, that amputation is to be preferred.

Malignant Tumours.—Removal of the limb, either by amputation through the shaft of the bone well above the growth, or preferably by disarticulation at the joint above, is the only operative treatment. Radiotherapy is carried out before amputating, and in certain cases after the operation. Even after early amputation the prognosis is grave.

Total Excision of the Scapula for Chondro-sarcoma.—The traditional operation is commenced by making incisions along the spine and the vertebral border of the bone, but the procedure recommended by Watson Cheyne is preferable in which the first step is ligation of the subscapular vessels.

The patient lies on his back, and an incision is made in the line of the axillary artery with its centre at the coracoid process; the cephalic vein, which is usually enlarged, is preserved; the muscles attached to the coracoid process are divided with scissors, and the axillary artery is defined and cleared; arising from it, about the level of the axillary border of the scapula, is the large subscapular artery, which is securely ligated and divided. In this dissection, care must be taken of the axillary vein and of the adjacent nerve trunks.

The patient is now placed on his sound side, to expose the posterior aspect of the scapula. The incisions to be made must include any skin likely to have become involved.

The usual two incisions follow roughly the vertebral border of the scapula and the line of the scapular spine. These two incisions meet at an angle, and when the skin and fascia are raised they form upper and lower flaps, which, when reflected, give the access required.

The spine is cleared by dividing the deltoid and trapezius muscles, and branches of the acromio-thoracic vessels are secured. The vertebral border is similarly cleared by dividing the rhomboids and serratus anterior muscles, and securing the posterior scapular vessels. Along the upper border of the bone, the levator scapulae, the omohyoid, and any remaining fibres of the deltoid are divided and the suprascapular vessels are secured. The inferior angle is cleared by dividing the latissimus dorsi muscle and any remaining bundles of the serratus anterior. The acromio-clavicular joint is opened, or the acromion may be divided with a Gigli saw. The clearance of the axillary border is comparatively easy if the subscapular vessels have been secured. Finally, the muscular and ligamentous attachments to the upper end of the humerus are divided; these include the triceps and long head of the biceps, the supra- and infraspinatus, the teres major and minor, and the subscapularis; the scapula is then rapidly disarticulated at the shoulder joint. The scapula, with the tumour, is removed, and attention is directed to securing any bleeding points and to the removal of enlarged glands from the axillary portion of the wound. The axillary nerve and the posterior circumflex artery are preserved, or the latter may have to be ligated at the lower border of the teres minor, while more medially the circumflex scapular artery must be ligated.

An attempt may be made to provide a fixed point for the head of the humerus by stitching the capsule and any available stumps of tendons to the clavicle. The muscles detached from the coracoid process are also sutured to the clavicle. The upper border of the deltoid is stitched to the trapezius and adjacent muscles, and the arm is placed in the attitude of right-angled abduction.

R. I. S.

CHAPTER VI

OPERATIONS ON JOINTS

General Principles. Arthrotomy. Excision. Arthroplasty. Arthrodesis. Puncture. Operations on Joints of Upper Extremity. Operations on Joints of Lower Extremity.

There are certain general principles applicable to all operations on joints, which, to avoid repetition, may be mentioned first. Although synovial membrane is more resistant to infection than was at one time thought, the opening of a healthy joint demands scrupulous attention to aseptic technique. The skin must therefore be carefully prepared. It is a good plan to carry out what is known as a 'two-day preparation'. The first preparation is performed in the evening two days before operation, the second on the day before operation, and the third on the morning of the day of operation. It is important that this preparation should cover a wide area. In the case of the knee it should include the foot and reach as high as the iliac crest. The surgeon must personally superintend the preparation of the skin and the disposition of the sterile mackintoshes and towels on the operating-table. He should put on two pairs of sterile gloves. After the skin incision is made, the sterilized towels are attached to the skin edges by tissue forceps or Michel clips. No skin surface should be exposed. The knife with which the skin incision is made is discarded, and the surgeon then removes one pair of gloves. The wound itself should not be touched except with instruments. The wound is sewn up in layers, and the stitches are inserted by means of instruments without handling the suture. In the ligation of vessels, also, instruments and not the fingers should be employed. Before stitching up the skin wound the towels are removed and iodine is applied to the skin surface. The dressing should be an abundant one for purposes of support and compression. If a sterile gauze roll is used in the form of a bandage, it must be applied loosely, as gauze does not permit of swelling. If elastic compression is required, it should be obtained by pressure of the bandage over cotton wool and not by the roll of gauze. The limb is secured on a suitable splint, or other appliance, with or without weight extension.

Opinion is divided regarding the advantages of employing a *tourniquet* in operations upon joints. The convenience of operating in a bloodless field is great, but may be counterbalanced by the increased risk of reactionary haemorrhage, which interferes with the healing of the wound, or may cause haemarthrosis. The prolonged application of a constricting bandage, moreover, is not infrequently

followed by paralysis of one or more of the nerve trunks pressed upon, particularly in the upper extremity. As a working rule it may be stated that if the operation is likely to be a prolonged one, the tourniquet should be dispensed with; while in short operations it may be employed, and it should not be removed until the compression dressings and bandage have been applied and the limb elevated.

The *incision* made to expose a joint should be as simple as possible consistent with affording free access, and should be placed so as to fall over the intervals between muscles, tendons, and ligaments in order that the least possible damage is inflicted on soft parts, and particularly on the nerves supplying the muscles that act upon the joint. The primary incision should always be planned so that it can be extended if it is found necessary to perform a more extensive operation than was at first contemplated.

In cutting down upon the capsule, special care should be taken not to damage the branches of nerves passing to muscles; and the attachments of the muscles and tendons acting upon the joints should be disturbed as little as possible.

The capsule is divided in the long axis of the limb, and is detached in continuity with the periosteum of the adjacent bones. For this purpose a sharp-edged instrument, such as an osteotome or chisel, is employed so as to raise the superficial lamellae of the cortex of the bone; the blunt-edged periosteal elevator, which raises only the fibrous layer, should not be used.

It is important to preserve the attachments of ligaments and tendons to bone by chiselling off the bony processes to which these structures are attached, and subsequently securing them in place again by peg or suture.

In operations necessitating the removal of articular cartilage and bone, the amount to be removed is determined by the extent and location of the disease, and by the function of the joint. When, for example, it is desired that ankylosis should occur between the exposed bony surfaces, as is frequently the case at the knee, the ends of the bones should be shaped so that they fit into one another in such a way as to favour sound osseous union, and they may be fixed by a bone graft. When, on the other hand, a movable joint is aimed [illegible]
of the [illegible]
ankylo[illegible]
a quantity of fat, should be interposed between them and stitched in position.

The term **Arthrotomy** is employed when a joint is opened for purposes of exploration or of drainage, for the removal of a loose body, or the excision of a displaced or torn intra-articular cartilage.

CHAPTER VI

OPERATIONS ON JOINTS

General Principles Arthrotomy. Excision. Arthroplasty. Arthrodesis. Puncture Operations on Joints of Upper Extremity. Operations on Joints of Lower Extremity.

There are certain general principles applicable to all operations on joints, which, to avoid repetition, may be mentioned first. Although synovial membrane is more resistant to infection than was at one time thought, the opening of a healthy joint demands scrupulous attention to aseptic technique. The skin must therefore be carefully prepared It is a good plan to carry out what is known as a 'two-day preparation'. The first preparation is performed in the evening two days before operation, the second on the day before operation, and the third on the morning of the day of operation. It is important that this preparation should cover a wide area. In the case of the knee it should include the foot and reach as high as the iliac crest. The surgeon must personally superintend the preparation of the skin and the disposition of the sterile mackintoshes and towels on the operating-table. He should put on two pairs of sterile gloves. After the skin incision is made, the sterilized towels are attached to the skin edges by tissue forceps or Michel clips No skin surface should be exposed The knife with which the skin incision is made is discarded, and the surgeon then removes one pair of gloves. The wound itself should not be touched except with instruments. The wound is sewn up in layers, and the stitches are inserted by means of instruments without handling the suture In the ligation of vessels, also, instruments and not the fingers should be employed. Before stitching up the skin wound the towels are removed and iodine is applied to the skin surface. The dressing should be an abundant one for purposes of support and compression If a sterile gauze roll is used in the form of a bandage, it must be applied loosely, as gauze does not permit of swelling. If elastic compression is required, it should be obtained by pressure of the bandage over cotton wool and not by the roll of gauze. The limb is secured on a suitable splint, or other appliance, with or without weight extension

Opinion is divided regarding the advantages of employing a *tourniquet* in operations upon joints. The convenience of operating in a bloodless field is great, but may be counterbalanced by the increased risk of reactionary haemorrhage, which interferes with the healing of the wound, or may cause haemarthrosis. The prolonged application of a constricting bandage, moreover, is not infrequently

active tuberculous disease; and in joints such as the hip and shoulder where the anatomy of the bones makes it difficult to appose sufficiently wide surfaces within the joint to ensure bony union.

Puncture of a joint may be carried out for diagnostic purposes, to remove fluid effusion or blood from the joint cavity, or, more rarely, for irrigation of the joint.

Operations on Joints of Upper Extremity

Operations on the Carpus

Reduction or Excision of the Dislocated Lunate.—If manipulative reduction fails in anterior dislocation of the lunate, reduction may be accomplished by open operation with the prospect of good function, provided it is done at an early date and provided interference with the blood-supply of the bone has not reached a degree sufficient to cause avascular necrosis. A longitudinal incision 7·5 cm. (3 in.) long is made along the radial border of the palmaris longus tendon. The median nerve and the tendon of flexor carpi radialis are retracted laterally and the flexor tendons of the fingers medially. The dislocated lunate is then exposed lying immediately proximal to the wrist-joint; it is devoid of attachments except for the stout ligamentous structure by which it is secured to the volar margin of the radius and which is now the sole source of blood-supply. With the wrist in extension, traction is applied to the fingers in order to open up the space which the bone normally occupies. It is then gently levered into position with the aid of a small skid, care being taken to inflict minimum damage to articular cartilage. If reduction can be accomplished, the incision is closed and in order to prevent re-dislocation the wrist is immobilized in a plaster case in palmar flexion. The plaster is changed and the neutral position adopted after three weeks.

If the case is of long standing and reduction proves impossible, the lunate must be excised. In these circumstances the wrist is immobilized in dorsiflexion for two to three weeks, when active exercise is instituted.

Operations on the Wrist

Arthrodesis.—Artificial fixation of the wrist is most frequently required in advanced arthritis, the most common cause of which is an old ununited fracture of the carpal scaphoid, or in infective arthritis or tuberculosis in the healing stage. Arthrodesis of the joint in slight dorsiflexion gives excellent function, especially in cases in which supination and pronation can be preserved. The movements will, of course, be lost in tuberculous or infective arthritis, but if their return

Excision or Resection of a joint implies the removal of all the articular structures—cartilage, bone, capsule, and synovial membrane—because they are either so diseased or so badly injured that recovery with a functionally useful joint cannot be expected.

Arthroplasty.—This operation is designed to restore mobility to an ankylosed joint. The procedure is essentially the production of an artificial pseudarthrosis, the joint surfaces being remodelled to a shape mechanically suitable for function, and covered with a lining membrane, usually fat-bearing connective tissue or fascia lata, which tends to prevent re-ankylosis and permits the surfaces to glide over one another. In recent years the introduction of metals such as vitallium, which are well tolerated by the tissues, has led to an advance in the technique of this operation So far, the greatest measure of success has been attained in arthroplasty of the hip-joint, in which a cup-shaped mould of vitallium is placed over the head of the femur to act as an 'interposition membrane' between it and a reconstituted acetabulum The use of this inert metal cup leads to the production of congruous joint surfaces covered by a firm, smooth, glistening lining which is well adapted to joint function.

Whatever method is used, at the end of the operation the limb is placed at rest in a splint, and sufficient extension is applied to separate the joint surfaces In two to three weeks' time, when the wound has healed and reaction has subsided, active mobilizing exercises are begun

Arthrodesis.—The aim of this operation is to bring about ankylosis in a joint that has been rendered functionless as a result of paralysis of the muscles which act upon it, or when a joint has been disorganized by disease or trauma. For example, by stiffening a flail knee-joint in the extended position, the lower limb may be rendered capable of supporting the body-weight, while by ankylosing a flail elbow in the flexed position, the usefulness of the hand may be greatly increased.

Intra-articular Arthrodesis consists in removing the articular cartilage from the ends of the bones so that wide raw bony surfaces are brought into contact and allowed to unite with one another. Stability in the optimum functional position and union are facilitated by driving a bone graft or grafts from one bone into the other across the joint space. Thereafter the joint is immobilized in a plaster case until there is clinical and radiological evidence of union.

Extra-articular Arthrodesis aims at stiffening the joint by passing a bone graft, sometimes free but often pedicled, from one bone to another, thus bridging the joint interval outside the capsule without disturbing the interior of the joint The method is especially useful when it is desired to attain ankylosis in a joint which is the seat of



FIG. 42. Lateral Incision for Exposure of the Right Elbow. (Kocher.)

Ulnar nerve
Anconeus
Origin of flexors detached
Insertion of triceps detached sub-cortically
Synovial layer

FIG. 43. Exposure of Elbow by Kocher's Method.
(The clearing of the humerus is in excess of requirements.)

is particularly desirable they can usually be regained, once arthrodesis is sound, by resection of 2·5 cm. (1 in.) or so of the ulna above the level of the inferior radio-ulnar joint

A straight incision 12·5 cm. (5 in.) long is made on the dorsal aspect of the wrist, starting over the middle of the third metacarpal and continuing upwards in the line of the radius. The tendons of the extensor digitorum communis are retracted to the ulnar side and the tendon of the extensor pollicis longus is mobilized from the dorsal tubercle of the radius and retracted to the radial side. A deep gutter 1·5 cm. (½ in.) wide is cut in the base of the third metacarpal, carpus, and radius, and an opening is made into the medullary cavity of the metacarpal distally and the radius proximally. A cortical bone graft, of width and thickness corresponding to the depth and width of the prepared bed but 1·5 cm. (½ in.) longer, is cut from the antero-medial surface of the tibia. The graft is placed in the gutter and the ends introduced in the openings in the corresponding medullary cavities in such a manner that the wrist is held in the required position of slight dorsiflexion by the locking of the graft into its bed (Brittain).

At the end of the operation a plaster cast reaching from above the elbow-joint to the heads of the metacarpals is applied over the usual dressings At the end of three weeks this initial plaster is changed for a skin-tight cast. This cast is retained for three months and then changed for one which permits elbow movements; the final plaster is retained for one month.

Operations on the Elbow

Puncture of the elbow-joint, either as a diagnostic or as a therapeutic measure, is carried out by inserting the needle into the joint from the postero-lateral aspect immediately above the head of the radius.

Exposure of the Elbow-joint.—For complete exposure of the elbow-joint the method of Kocher is most suitable as it aims at dislocating the joint medially with a minimum of injury to muscles and their nerve supply. With the elbow almost completely extended and resting on its ulnar border, and while the assistant grasps the hand and pulls upon it, an incision is made beginning at the lateral supracondylar ridge two or three fingers' breadth above the level of the joint, passing vertically downwards to the head of the radius, and thence along the lateral border of the anconeus to the posterior border of the ulna, about 7·5 cm. (3 in.) below the tip of the olecranon, and finally curving over the medial suface of the ulna (Fig. 42). The upper part of the incision enters the intermuscular space between the brachio-radialis and the radial extensors in front and the triceps



Fig. 42. Lateral Incision for Exposure of the Right Elbow. (Kocher)

Ulnar nerve
Anconeus
Origin of flexors detached
Insertion of triceps detached sub-cortically
Triceps detached sub-periosteally
Synovial layer

Fig. 43. Exposure of Elbow by Kocher's Method.
(The clearing of the humerus is in excess of requirements)

behind. In its lower part it passes down to the bone, between the extensor carpi ulnaris and the lateral border of the anconeus, and divides the strong capsule over the head of the radius. It will be observed that the incision corresponds accurately to the interval between the muscles supplied by the branches of the radial nerve and those supplied by the posterior interosseous. The lateral head of the triceps, with the posterior and upper part of the capsule, are

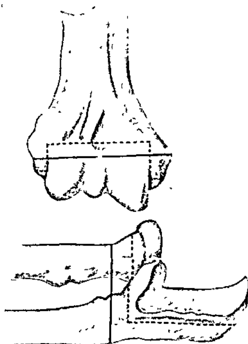


FIG. 44 Lines of Sections of Bones of Elbow-joint. The continuous lines show those required in excision; the dotted lines show those employed in arthroplasty.

detached from the humerus, the anconeus from the posterior surface of the ulna, the insertion of the triceps from the tip of the olecranon, and, on the joint being extended, the combined flap of triceps and anconeus is displaced over the olecranon to its ulnar side.

The lateral ligament, the attachment of the extensor tendons, and the capsule attached to the lateral epicondyle are separated subcortically by a sharp instrument and drawn forwards. The joint has now become so movable that the forearm can be completely dislocated medially, and yet the extensor apparatus is preserved in its continuity and the medial ligament is still intact. The ulnar nerve need not be seen while clearing the olecranon and medial condyle; there is no risk of injuring it if each successive cut is made upon the bone.

With this exposure either **arthrodesis** or **arthroplasty** can be carried out. The decision whether a movable or ankylosed elbow is to be preferred depends on a number of circumstances which include not only the nature of the disease for which operation is being undertaken, but also the sex and the occupation of the patient. Arthroplasty is more suitable for cosmetic purposes and would obviously be the operation of choice in some occupations. It should be remembered, however, that although in the most favourable cases an almost complete range of motion may be obtained, the joint lacks the strength and stability of a normal joint. It is for this reason that in a manual worker arthrodesis is frequently the preferable operation. The optimum position for fixation is in the region of right-angled flexion, with a preference for an angle less rather than more than a right angle, so that the patient may put his hand into his pocket and also to his mouth. It should be realized that if the head of the radius takes part in the fusion, supination and pronation will be lost, and it is therefore necessary to find out what position within the range of rotation is most suitable for the patient's occupation. Writing, for example, requires a fair degree of pronation, while the handling of a spade, in the left arm at least, requires almost full supination.

Should **arthrodesis** be required, the raw bone-ends, cut to fit each other as accurately as possible, are fitted together at the required angle and stabilized by driving one or two bone grafts 7–10 cm. (3–4 in.) long and 1 cm. (½ in.) wide from the olecranon process up into the lower end of the humerus. These grafts are of considerable help in producing rapid consolidation in a joint in which it is not easy to produce fusion, because of the difficulty of maintaining the bone ends in apposition and the fact that two long levers meet with the greatest stress acting at the point of contact between the bones. The plaster cast which is applied at the end of the operation should be changed in three to four weeks' time in order to maintain the closeness of fit which is necessary to attain complete immobilization at this joint. This cast must be retained for a further three months, and thereafter a leather corset may be necessary for six months to a year.

In **arthroplasty** the head of the radius is resected and the trochlear notch enlarged and deepened; the lower end of the humerus is shortened and remodelled so that a single condyle the whole breadth of the bone is formed. A free transplant of fascia lata is then wrapped round the reconstructed surface of the humerus and secured with chromic catgut sutures. The remainder of the flap is

Operations on the Shoulder

Puncture.—The needle is inserted just beneath the lateral margin of the acromion process and passes directly into the joint through the deltoid muscle.

Methods of Access to the Shoulder-joint.—*The Anterior Route.* This is perhaps the most generally useful approach for operations on the joint and also for access to the upper extremity of the humerus. The incision commences upon the clavicle, above and lateral to the coracoid process, and passes downwards and slightly laterally along the anterior border of the deltoid muscle. The cephalic vein is drawn medially along with the pectoralis major, and the deltoid is retracted laterally (Fig. 45). The mobility of the deltoid may be improved by dividing some of the anterior fibres of the muscle close to their origin from the clavicle, and it is usually necessary to secure the descending branch of the acromio-thoracic artery.

The coracoid process and the muscles attached to it—the pectoralis minor, the coraco-brachialis, and the short head of the biceps—are now well seen At the lateral border of the last named the synovial sheath of the long tendon of the biceps can be opened and split up into the joint. Should it be desired to expose the head of the humerus fully, the arm is rotated laterally and the subscapularis insertion separated subcortically along with the capsule. By rotating the arm medially, the insertions of the spinati are dealt with in a similar fashion. It is now possible to project the humeral head out of the wound.

The Lateral Route This may be utilized alone or combined with the anterior route The incision passes over the acromion in an antero-posterior direction. The attachment of the deltoid to the acromion is divided and the muscle turned down so as to expose the joint. This method is more applicable to operations aiming at arthrodesis where the injury to the deltoid is not of serious significance

Arthrodesis of the Shoulder.—This operation may be indicated in disease or injury as a means of eliminating pain, or to improve the function of a joint fixed in adduction or useless as a result of paralysis of the deltoid The usefulness of the limb after arthrodesis of the shoulder depends on the efficiency of the muscles controlling the scapula, and the operation should not be performed unless these muscles and those controlling the elbow and hand are normal.

The joint is opened in the manner described above and free access to the head of the humerus and the glenoid cavity obtained. The joint surfaces are then carefully denuded of cartilage. The under surface of the acromion is rawed. The acromion is then fractured

at its base in order that it may be swung down into contact with the greater tuberosity of the humerus in which a cleft is cut to receive it.

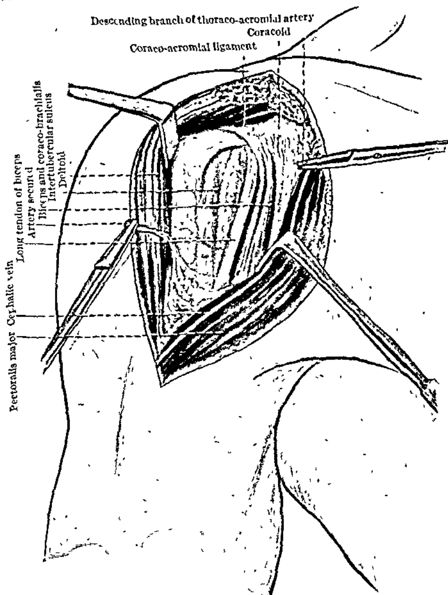


FIG. 45 Exposure of Right Shoulder-joint by Anterior Incision, 1st stage.

After operation the shoulder is immobilized in a plaster spica in the position of election; in 70 degrees of abduction, the elbow forward so that it lies in the same plane as the anterior chest wall and the humerus laterally rotated some 15–20 degrees. After the lapse of twelve weeks the top half of the plaster is removed and the patient

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used through an incision 15·5 cm. (6 in.) long, starting at the posterior margin of the deltoid, passing over the axilla, and proceeding down the lateral border of the scapula to a point close to its inferior angle. Through this incision the neck of the humerus and the lateral border of the scapula are exposed. A stout tibial graft is placed with one end impacted into the shaft of the humerus, and the other end split and fixed against and partially morticed into the lateral border of the scapula. This graft acts as a strut between the scapula and the humerus and has the advantage that it eliminates the risk of secondary adduction deformity.

Operation for Old-standing Dislocation of the Shoulder.—In cases of dislocation of the shoulder of more than a few weeks' standing there is a danger that forcible attempts at reduction may result in tearing of important blood-vessels or nerves to which the head of the dislocated bone may have contracted adhesions. In these circumstances operation may be indicated. If the condition is of any considerable duration, it is a wise plan to employ gentle, steady traction for a few days prior to operation, otherwise the adaptive shortening of muscles and other soft tissues may make the difficulties even of operative reduction insurmountable. The head of the humerus is exposed by the anterior route, separated under direct vision from adhesions, and replaced in the glenoid cavity. If there is a coexistent fracture of the neck of the humerus, this is also reduced. In cases of long standing, where reduction proves impossible, and in cases of fracture-dislocation where the head of the bone is comminuted or reduction of the fracture otherwise impracticable, the head may be excised and the upper extremity of the humerus placed in the glenoid cavity.

Operations on Joints of Lower Extremity

Operations on the Ankle-joint

Arthrodesis of the Ankle-joint may be indicated in osteo-arthritis, usually the outcome of a mal-united fracture, infective arthritis, or healed tuberculosis.

An incision should be used which gives free access to the whole of the joint so that all cartilage can be completely removed from the joint surfaces. The Kocher's lateral hooked incision will be found satisfactory. It begins a hand's breadth above the lateral malleolus, about midway between the fibula and the tendo calcaneus, and curves round the lateral malleolus, passing fully 2 cm. (1 in.) below it, to terminate at the lateral border of the peroneus tertius, thereby avoiding the musculo-cutaneous nerve. The sheaths of the peroneus longus and brevis are exposed and slit upwards behind the fibula as

encouraged to raise the arm out of the spica in order to exercise the scapular muscles. The plaster may be discarded in a further four to

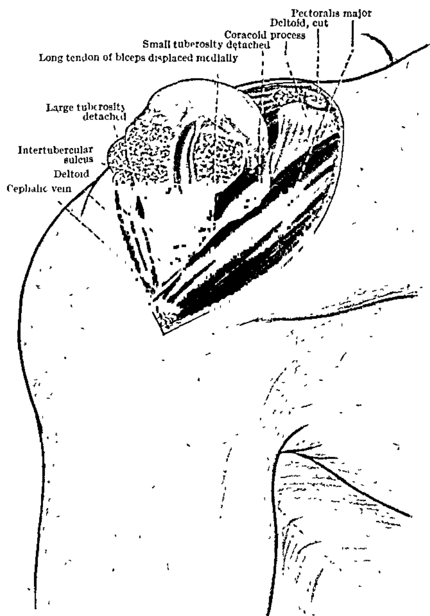


Fig. 46 Exposure of Right Shoulder-joint by Anterior Incision, 2nd stage

eight weeks or when the ankylosis is considered to be sound and the scapular muscles are redeveloped.

In tuberculosis an *extra-articular arthrodesis* may be required and is best performed by the method of Brittain. A posterior approach is

far as the upper end of the wound. To obtain the best access, the tendons must be divided, but each is secured with silk in order that it may be sutured at the end of the operation. The periosteum is separated from the lateral and lower aspects of the lateral malleolus, and the ankle-joint opened in front of it (Fig. 47). The capsule is detached along the lateral surface of the talus, and the three bands of the lateral ligament are divided close to their attachments to the lateral malleolus. The capsule, together with the periosteum, is then separated from the anterior border of the tibia as far as the medial malleolus, and the flap, including the extensor tendons, is hooked upwards The structures on the back of the fibula are also separated subperiosteally, so as to leave the tendon sheaths of the peronei in relation to the periosteum (Fig. 48). The foot is now forcibly dislocated medially over the medial malleolus, until the sole looks almost directly upwards, as shown in Fig. 48.

This exposure admits of thorough examination, not only of the ankle-joint, but also of the inferior tibio-fibular joint. In the typical operation the joint surfaces are denuded of their cartilage and the upper surface of the talus is cut to fit into the mortice of the lower ends of the tibia and fibula. Should this socket be too large, its lateral width can be diminished and a close fit assured by an osteotomy of the base of the lateral malleolus The foot is then placed in position and, after the divided tendons and skin have been sutured, is immobilized in plaster in 5–10 degrees of equinus, depending on whether the patient is male or female, the degree of equinus corresponding to the height of heel in common use.

The plaster is retained for a total of four months, weight-bearing in the plaster being permitted during the final four weeks of immobilization.

In recent years it has been the practice to employ a bone graft crossing the joint in order to secure additional stability and more certain consolidation. If this method is used, the skin incision should be placed over the anterior aspect of the tibia, terminating below and in front of the lateral malleolus. The operation proceeds in the manner described, but is completed by driving a sliding graft taken from the tibia into the body of the talus while the foot is held in the required position

Operations on the Knee-joint

Puncture.—A point is selected on the lateral side of the suprapatellar bursa above the level of the superior border of the patella and the needle entered at right angles to the skin.

Arthrotomy for Drainage.—In cases of acute infective arthritis which have failed to react to aspiration and chemotherapy, free

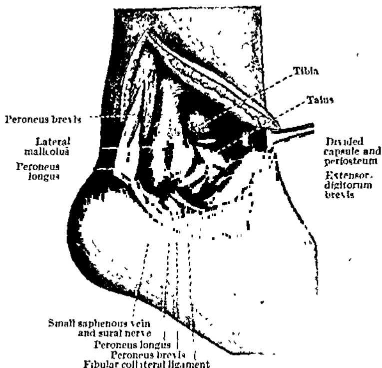


FIG 47. Exposure of Right Ankle by Kocher's Incision, 1st stage.

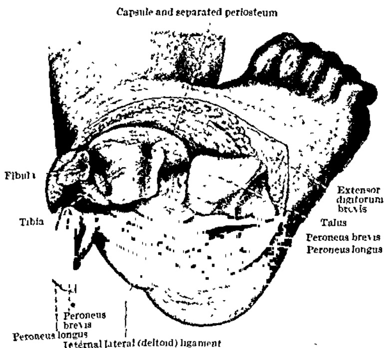


FIG. 48 Exposure of Right Ankle by Kocher's Incision The Foot is dislocated inwards.

for a variety of conditions which include tuberculosis in the adult which has reached the healing stage following a period of conservative treatment, certain cases of chronic painful arthritis, especially when

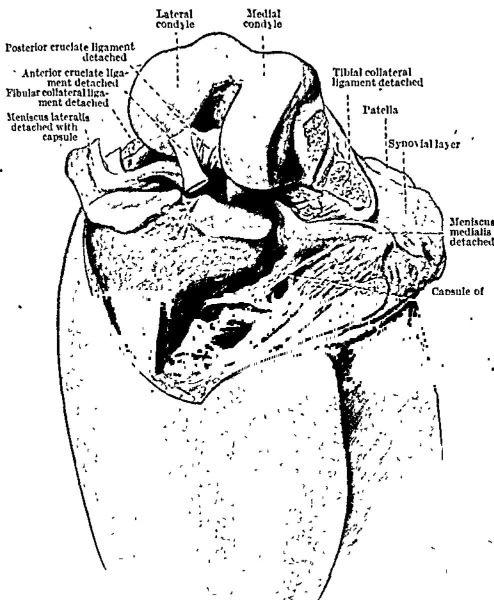


Fig. 51. Excision of Knee, 2nd stage.

associated with irreducible flexion contracture, fractures involving the articular surfaces, and irrecoverable paralysis of the quadriceps apparatus.

An anterior midline incision is made which extends from the upper

drainage may be required. This is accomplished through two incisions, one on each side of the patella, extending from the upper limits of the suprapatellar bursa above, to the level of the joint line below. If these incisions alone are considered to be inadequate,

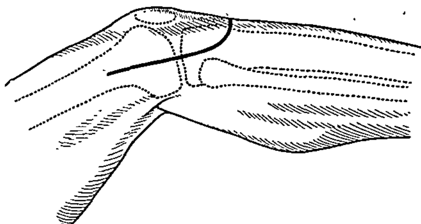


FIG 49 Incision for Excision of Right Knee, showing relation to bones.

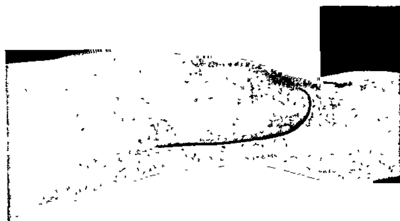


FIG. 50 Lateral J-incision for Excision of Knee. (Kocher.)

the retrocondylar pouches may be drained by passing a pair of forceps from the anterior incisions and cutting down on them in the popliteal fossa. On the medial side the director is passed between the medial femoral condyle and the medial ligament above the attachment to the medial semilunar cartilage; on the lateral side it passes freely backwards lateral to the poplitéus tendon.

Arthrodesis of the Knee-joint.—This operation is performed

the head of the femur and upper margin of the acetabulum are revealed.

If a wider exposure of the acetabulum, such as is necessary for arthroplasty, is required, the tendon of rectus femoris is divided immediately below its origin and reflected from the anterior capsule. In addition, the periosteum between the anterior superior and anterior inferior spines is incised and the iliacus stripped subperiosteally from the margin of the iliac fossa and a pack inserted.

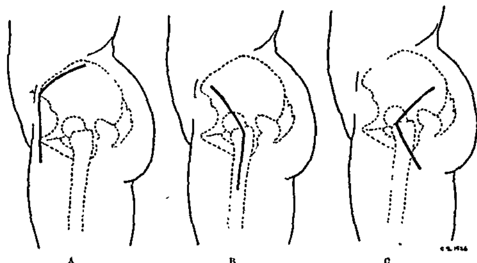


FIG. 52. Incisions to explore Hip-joint.

A. Smith-Petersen's Method.
B. Matthieu's Method.
C. Kocher's Method.

The Posterior Route (Kocher). An angled incision is made which begins about 2 cm. ($\frac{3}{4}$ in.) below and lateral to the posterior superior iliac spine and passes forwards and laterally parallel to the fibres of the gluteus maximus muscle, to the anterior superior angle of the greater trochanter, and thence downwards and backwards to the posterior inferior angle of the greater trochanter (Fig. 52c). The fleshy portion of the gluteus maximus above and behind the trochanter is split in the direction of its fibres and the tendinous portion is divided until the upper part of the tendinous origin of the vastus lateralis is exposed (Fig. 53). On retracting the edges of the gluteus maximus, the following structures are exposed from above downwards: a layer of fatty tissue occupying the hollow above and behind the trochanter, the insertion of the gluteus medius covering the upper and anterior part of the trochanter and, lower down, the vastus lateralis. Below the gluteus maximus is the piriformis, and still lower are the obturator internus, the gemelli, and the upper

limit of the suprapatellar bursa to a point about 20 cm. (8 in.) down the tibial shaft. The quadriceps tendon is split in the same line, beginning at the upper extremity of the bursa and continuing down over the patella to the tibial tubercle. The patella is dissected out and discarded and the capsule erased from the medial and lateral tibial condyles. This provides access to the suprapatellar bursa and lateral compartments to permit the synovial lining to be excised. The articular surfaces of the femur and tibia are removed by means of a saw or osteotome in such a manner that any deformity is corrected and the best possible apposition of the greatest area of raw bone obtained. The removal of the articular cartilage, semilunar cartilages, and cruciate ligaments gives access to the posterior compartment and allows any remaining diseased tissue to be excised. When the removal of bone and soft tissue has been completed, the two raw surfaces are brought into apposition and stabilized by driving a bone graft, cut from the crest of the tibia, from below upwards through the tibial table into the femur. Alternatively two bone grafts may be used which cross the joint in the form of an X after the manner of Brittain. The split patellar tendon is brought together with interrupted catgut sutures and the skin incision closed

The only satisfactory method of immobilization for an arthrodesis of the knee is a plaster spica which extends from the toes to the iliac crest. Weight-bearing in a calliper is usually possible after four months.

Operations on the Hip-joint

Puncture.—The needle is inserted directly over the head of the femur at the mid-point of a line joining the anterior superior iliac spine and the symphysis pubis, and is passed directly backwards.

Method of Access to the Hip-joint.—*The Antero-lateral Route* (Smith-Petersen) The incision begins about the middle of the crest of the ilium and passes forward to the anterior superior spine and thence distally and laterally for 12 or 13 cm. (5 or 5¼ in). The attachments of the gluteus medius and tensor fasciae latae muscles are divided about 1·5 cm (½ in.) from the iliac crest and the gluteus medius is stripped from the external surface of the ilium by subperiosteal dissection. The intermuscular plane between the sartorius medially and the tensor fasciae latae laterally is defined The ascending branch of the lateral circumflex femoral artery is seen about 5 cm. (2 in.) below the joint and must be divided between ligatures. About 2 cm. (¾ in) below the anterior superior spine the lateral cutaneous nerve is seen as it passes over the sartorius and is retracted to the medial side. The capsule of the hip-joint is exposed on the lateral border of the rectus femoris, and as it is incised transversely

rotates the thigh medially, thereby projecting the head of the bone against the capsule. The opening in the capsule is enlarged up to the acetabulum and down towards the trochanter, and the head of the bone is made to appear through it by rotating the limb farther medially and pushing the thigh vigorously upwards and backwards. If

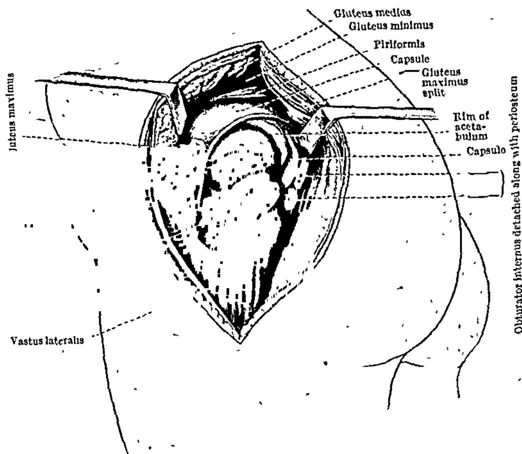


FIG. 54. Excision of Hip by Kocher's Method, 2nd stage.

the ligament of the head is still present, it should be divided at its attachment to the femur; the head is then dislocated backwards and the acetabulum is now accessible.

Radical Drainage of the Hip (Girdlestone).—In acute pyogenic arthritis which has failed to react to immobilization, aspiration, and chemotherapy, and in chronic infection complicated by sinuses and secondarily infected tuberculosis, radical drainage of the joint may be required. Neither the anterior nor the posterior route provides free access or effective drainage. The radical method described by Girdlestone aims at virtual 'saucerization' of the joint by an approach through a lateral incision at right angles to the muscle and fascial

fibres of the quadratus femoris. The inferior gluteal vessels and the sciatic and posterior cutaneous nerves are not usually exposed.

The next step is to detach the insertion of the gluteus medius from the trochanter; in the child this is easily done with the knife, a slice of cartilage being detached with the tendon. In the adult the hammer and chisel are employed to detach a thin layer of bone along with

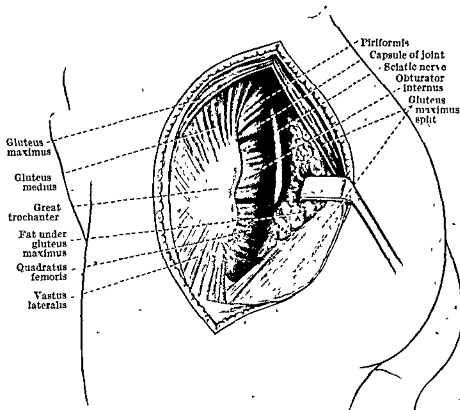


FIG. 53 Kocher's Operation for Disease of the Hip, 1st stage

the tendon (Fig. 54). By retracting the separated insertion of the gluteus medius upwards and forwards with a double sharp hook, the insertion of the gluteus minimus is reached, and may, if necessary, be detached from the anterior border of the trochanter. If the head of the bone is in the acetabulum, the tendon of the piriformis also is detached from the trochanter and retracted forwards with the glutei, or if the head has been displaced upwards it is retracted backwards with the obturator internus and gemelli, after they have been detached from the trochanter The posterior part of the capsule, after being fully exposed, is incised over the projecting head of the femur; this step is made easier if the assistant flexes, adducts, and

at the hip than at other joints because only small areas of bone can be brought into contact.

The operation may be indicated in such conditions as unilateral osteo-arthritis giving rise to severe pain and in tuberculous disease at the healing stage.

Two methods are in common use:

The *intra-articular* operation, which is most suitable to young adults suffering from unilateral osteo-arthritis who are fit to withstand such a formidable procedure and the prolonged immobilization which is necessary to secure sound arthrodesis.

The operation is performed through the antero-lateral (Smith-Petersen) approach. The articular surfaces are denuded of cartilage and opposing surfaces of raw bone brought into intimate contact; at the same time any deformity which may be present is corrected. Additional fixation and more rapid union may be secured by driving a long tri-flanged nail up from the base of the greater trochanter through the upper part of the head into the solid bone of the ilium either at the termination of the formal operation or two to four weeks later (Watson-Jones).

Immobilization is maintained by a close-fitting plaster spica which is retained from three to six months.

Extra-articular arthrodesis is used in tuberculosis, where it is undesirable that the operative field should enter the area of disease, but is also applicable to certain cases of osteo-arthritis, infective arthritis, and congenital dislocation. With Brittain's method, the operation consists of a subtrochanteric osteotomy (p. 97) through which the ischium immediately below the acetabulum is divided with an osteotome and a space made in it to receive a large flat bone graft taken from the antero-medial surface of the tibia. This graft is embedded deeply in the ischium in such a way that its outer portion is placed between the fragments of the osteotomy.

Arthroplasty of the Hip.—The extreme difficulty of locomotion, and the impossibility of sitting in a chair, in bilateral ankylosis of the hip-joints arising as a result of pyogenic arthritis, spondylitis ankylopoietica, or other condition, makes arthroplasty of one hip a most desirable procedure. The operation may also be used in conditions such as traumatic osteo-arthritis for the relief of pain, but as a rule arthrodesis is preferable to arthroplasty in unilateral hip disease.

The operation is performed through either the Smith-Petersen or the Kocher incision, both of which provide free access to the acetabulum and head of the femur. After opening the capsule, the ankylosis is divided along the line of the old joint with a special curved osteotome and the head of the femur dislocated. A new acetabulum is reamed out and the head of the femur remodelled in such a way

planes and a wide resection of the abductors and greater trochanter. The main nerves and arteries in front and the sciatic nerve behind are not disturbed or endangered. The loss of the abductors is of no consequence if the hip ultimately becomes ankylosed, and of little consequence if pseudarthrosis is established.

A long transverse incision is made from a point 2·5 cm. (1 in.) behind and below the anterior superior spine and is carried backwards so that the centre of the incision is about 2 cm. (¾ in.) above the greater trochanter. When the skin edges are retracted, a wide ellipse of gluteal fascia covering the gluteus medius and maximus is exposed. Two deep incisions are now rapidly made by successive sweeps of the knife. The upper incision, directed medially and downwards, divides the glutei down to the ilium just above the acetabulum; the lower incision, directed medially and slightly upwards, exposes the outer side of the base of the greater trochanter, which is at once divided by a broad osteotome directed obliquely upwards towards the trochanteric fossa The whole mass of tissue consisting of glutei and greater trochanter is removed and haemostasis established. The upper and outer aspect of the capsule of the joint is now exposed. The capsule and synovial membrane are removed, revealing the underlying portions of the neck and head of the femur and of the acetabular rim. The next step depends on the nature of the condition for which the operation is performed. If the infection is acute or the head of the femur necrotic, the neck is divided near its base and the femoral head removed, a manœuvre which is facilitated by removal of the upper acetabular rim All the articular cartilage is scraped out of the acetabulum and necrotic bone curetted If the joint is already ankylosed, it is undesirable to remove the head of the femur. The cavity is lightly packed with vaseline gauze.

The patients in whom this operation is required are frequently debilitated by pain and toxaemia, and as the procedure of necessity entails some loss of blood, transfusion is usually advisable during or at the termination of the operation

If the head and neck of the bone have been removed, it is important that upward displacement of the femur in relation to the ilium should be prevented, as this would tend to close the drainage opening and produce considerable shortening of the limb The position must therefore be maintained by fixed traction on a frame or by a close-fitting complete plaster spica

If the subsequent treatment is satisfactory, the result of the operation will be ankylosis in good position or pseudarthrosis The large gaping wound heals rapidly and leaves a surprisingly narrow scar.

Arthrodesis of the Hip.—Arthrodesis is more difficult to obtain

processes in the midline. The joints of the articular processes are destroyed by curetting out their cartilaginous surfaces, proceeding systematically from one vertebra to another. The small bone-flaps are raised from each lamina with a bone gouge, one turned upwards and one downwards, so as to make contact with the laminae above and below. The spinous processes are broken downwards, using a specially constructed bone forceps, so that the tip of the process comes in contact with the spine of the vertebra below. The entire periosteal sheath is brought together and sutured and the subcutaneous tissues and skin closed. The spine is immobilized in a previously prepared bivalved cast for a period of eight weeks, after which a brace is employed until fusion is solid and symptoms have entirely subsided, which usually requires about one year.

Similar operations may be employed to immobilize the spine in cases of fracture.

Operation for Disease of the Sacro-iliac Joint.—Tuberculous disease of this joint usually begins in the sacrum, a part of which is liable to necrose, forming a sequestrum. Abscess formation is of frequent occurrence. Radiographs of the sacro-iliac joint are often unsatisfactory, and do not demonstrate any changes until there has been extensive destruction In advanced cases the articular surface of the sacrum and ilium are eroded, the joint space appears broader than normal, and the area is surrounded by a shadow of increased density, indicating abscess formation. Operative fusion of the sacro-iliac joint affords the most satisfactory method of treatment, except in the advanced stage with abscess formation, when the probability of procuring osseous formation is less.

A curved incision is made from the posterior superior spine along the crest of the ilium, two-thirds of the distance to the anterior superior spine. The incision is carried down to the bone, and the reflection of periosteum started. A second incision is made from the posterior superior spine in the direction of the fibres of the gluteus maximus for a distance of 8–10 cm. (3–4 in.). This incision is carried through the subcutaneous fat and gluteal fascia, and the fibres of the gluteus maximus are separated by blunt dissection until the junction of the ilium and sacrum between the superior and inferior spines is reached. The superior gluteal nerve and artery emerge at the anterior portion of the greater sciatic notch and give off posterior branches which are encountered by the straight limb of the incision, and sometimes cause considerable bleeding. They have to be sacrificed in order to get a satisfactory exposure.

The flap thus outlined is reflected subperiosteally, exposing the posterior portion of the lateral surface of the ilium. If the sacro-iliac joint is projected on the lateral surface of the ilium it will be found

that the normal curves and mechanics of the joint are reproduced. A vitallium cup is selected of a size which will fit both the head of the femur and acetabulum loosely. The head of the femur covered by the metal mould is then returned to the acetabulum, the divided muscles sutured in position, and the incision closed. The limb is put up in weight and pulley traction and active movement encouraged about the end of the second week.

Operations for Fixation of the Vertebral Column in Tuberculous Disease

To hasten the fixation of the spine and to prevent progressive angular deformity during the consolidation of the bones after the disease has been arrested, the operations devised by Hibbs and by Albee have proved most useful. The Albee operation is attended by less shock, and may be accomplished in a much shorter space of time. Hibbs's procedure has the advantage of decreasing external deformity and can be employed regardless of the degree of deformity.

Albee's Operation.—Through a curved longitudinal incision the spinous processes of the affected vertebrae and of a healthy one above and below are exposed The supraspinal and interspinal ligaments are divided longitudinally, and the spinous processes are split in half with a heavy sharp osteotome nearly down to the neural arches; one half of each spinous process is fractured completely at its base and displaced laterally. The bed thus prepared presents a median longitudinal gutter into which is placed a graft of sufficient length, which has been removed from the tibia by a motor saw. The graft is immobilized by sutures of kangaroo tendon or catgut, and the spinal muscles, ligaments, and fascia are sutured over this. The graft may be sufficiently long to include at least two vertebrae above and two below After the wound is closed the patient is placed on a Bradford frame or in a plaster cast for six to eight weeks

Experience has shown that transplants of bone are not so successful in children as in adults. These operations are merely a substitute for prolonged fixation; they are curative only indirectly, in so far as they render the spine rigid, and so favour the natural reparative processes. A spinal brace must, therefore, be worn for the best part of a year after the patient gets up.

Hibbs's Operation —A longitudinal incision is made directly over the spinous processes through the skin, supraspinal ligament, and periosteum to the tips of the spinous processes The periosteum is split over the upper and lower borders of the spinous processes and the laminae, and stripped back to the base of the transverse processes The operation aims at inducing fusion at five distinct points—the laminae and the articular processes on each side and the spinous

processes in the midline. The joints of the articular processes are destroyed by curetting out their cartilaginous surfaces, proceeding systematically from one vertebra to another. The small bone-flaps are raised from each lamina with a bone gouge, one turned upwards and one downwards, so as to make contact with the laminae above and below. The spinous processes are broken downwards, using a specially constructed bone forceps, so that the tip of the process comes in contact with the spine of the vertebra below. The entire periosteal sheath is brought together and sutured and the subcutaneous tissues and skin closed. The spine is immobilized in a previously prepared bivalved cast for a period of eight weeks, after which a brace is employed until fusion is solid and symptoms have entirely subsided, which usually requires about one year.

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that the inferior border corresponds with the greater sciatic notch, and the anterior border with the median gluteal line. A rectangular window is now cut through the ilium within the projected area of the joint. The thickness of the ilium just above the greater sciatic notch is considerable, sometimes as much as an inch, but if care is taken the entire block of bone from the outer to the inner table of the ilium may be removed in one piece. Upon removal of the window the cartilaginous joint surface of the sacrum comes into view, and is removed along with its cortex, giving a good exposure of cancellous bone This results in a rectangular channel bordered on all sides by cancellous bone, extending from the ilium through the sacro-iliac joint into the sacrum.

After removing the cartilage and cortex from the block of bone removed from the ilium this is replaced in its original site and countersunk, so that its cancellous surface comes into contact with the cancellous bone of the sacrum. The flap is now returned to its place, and the periosteum and soft parts are sutured in layers (Smith-Petersen).

I. S. S.

CHAPTER VII

OPERATIONS ON MUSCLES AND TENDONS

Tendon Suture—Subcutaneous Tenotomy—Sliding Operations—Tendon Fixation—Transplantation of Tendons—Repair of Rupture of Tendons—Dislocation of Peroneal Tendons—Lengthening of Tendons—Operations for Torticollis—Operative Treatment of Infections of Hand.

Tendon Suture.—*Primary* end-to-end suture of divided tendons should be carried out as soon as possible after wounding in all cases in which the local and general conditions permit. The pre- and post-operative use of penicillin has extended the field for primary suture. After adequate exposure and identification of the cut ends, suture is carried out by the method of Bunnell (Fig. 55), using No. 60 linen thread or size 40 stainless steel wire The skin and subcutaneous tissue must be accurately closed over the sutured tendon. The part is splinted for a period of not less than sixteen days in such a position that the sutured tendons are relaxed.

Excellent results are usually obtained if the sutured tendon does not lie in a fibrous tunnel or sheath, e.g. extensor tendons of hand, but when the sutured tendon lies in such a sheath, as in the fingers, the functional result of tendon suture is frequently poor. In such cases it is not advisable to attempt to suture the sheath.

When *secondary* suture is called for after accidental injuries the ends of the tendons must be freshened by cutting them transversely with a sharp knife. It may be difficult to bring the ends of the tendon together without tension after they have been freshened. A long incision may be necessary to reach the retracted proximal end, and even then contraction of the muscle may make it difficult to obtain sufficient elongation. By infiltrating the belly of the muscle concerned with ½ per cent. novocain, contraction may to some extent be overcome, and by flexing the joints over which the tendon passes additional relaxation may be obtained. If a gap still persists, it may be filled by a free tendon graft taken from another tendon that can be spared, such as the palmaris longus.

Subcutaneous Tenotomy.—This operation, which has been largely replaced by open operation, consists in dividing a tendon by means of a short, narrow-bladed knife. The tenotome is made to puncture the skin and the blade is passed either between the skin and the tendon or underneath the tendon according to circumstances. The tendon is then put upon the stretch and cut across. The limb is fixed in the corrected position and the gap in the tendon fills with new fibrous tissue.

Sliding Operations.—In certain cases of flexion contracture at

the hip, in pes cavus, and in Volkmann's contracture of the forearm, individual muscles or groups of muscles may be separated from their proximal attachments and moved bodily nearer to their distal insertions.

Tendon Fixation.—In paralytic conditions a paralysed tendon may be made use of as a mechanical sling to correct deformity; for example, in drop-foot the tibialis anterior and the peronei tendons may be cut across and fixed to the tibia and fibula respectively by

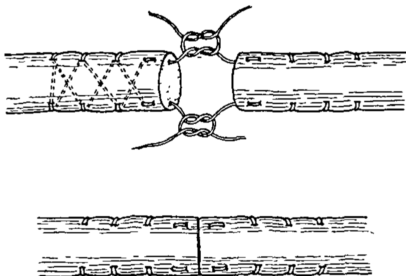


FIG. 55. Placement of Sutures for End-to-end Suture of Divided Tendon.

passing them through drill-holes in the bones. The results are satisfactory in adults, but in children the fixed tendon is liable to stretch.

Transplantation of Tendons.—*Indications.* This operation is performed for such conditions as poliomyelitic paralysis in the chronic stage, irreparable injury of peripheral spinal nerves, obstetric paralysis, and destructive injuries of muscles and tendons. The purpose of the operation is to replace a paralysed or destroyed muscle by a normal muscle that is physiologically adapted to act as a substitute, thus restoring or improving muscle balance and improving function. Transplantation is used also to assist the restoration of movement at the ankle-joint in conjunction with stabilization operations, such as talectomy, Dunn's operation (p 156), and mid-tarsal arthrodesis. The tendency is to restrict its use to conditions in which the paralysis is limited and reinforcement can be obtained from the immediate vicinity A simple operation should be aimed at, carefully judged to suit the individual case, and anatomically and mechanically sound.

The operation should not be done until every effort has been made to restore the paralysed muscle by other means. In poliomyelitis, for example, no matter how long the paralysis has existed, the recoverability of the muscle is to be tested by keeping it completely relaxed for six months, before considering tendon transplantation. It is not, as a rule, wise to perform the operation before the age of

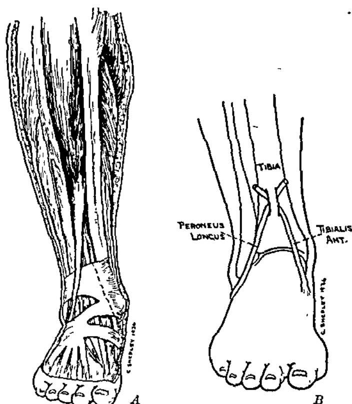


FIG. 56. *A*. Transplantation of Tibialis Anterior to Lateral Side of Foot for Talipes Varus.
B. Tenodesis for Paralytic Pes Equinus.

five, and generally one should wait a good deal later than this, provided deformity is not rapidly increasing.

Certain principles govern the transplantation of tendons:

(1) Muscles selected for transplantation should be sufficiently strong for their new work (2) Their transfer must not unduly weaken the group from which they are taken (3) The transplanted muscle must be capable of being re-educated Therefore its normal physiological action should correspond closely to, or should be synergic with, that of the muscle it is to replace. (4) The new course of the transplanted muscle should be as nearly as possible in a straight line

from its origin to its new insertion. (5) The transplanted tendon should be fixed to its new insertion under a normal physiological degree of tension.

To illustrate the principles on which the procedure is based, transplantation of the peroneus longus to the medial side of the foot in severe paralytic pes valgus may be cited. An incision 4 cm. (1½ in.) long is made on the lateral side of the tarsus in the line of the tendon where it passes under the foot. The foot is adducted and plantarflexed and the tendon cut across as near to its insertion as possible. An incision of 8 cm. (3 in.) is then made at the junction of the lower and middle thirds of the fibula, and the tendon identified. It is pulled out through this incision, and a subcutaneous tunnel is made towards the first cuneiform bone, down which the tendon is passed by attaching it by a quilted stitch to a special tendon-carrier, or to a strong probe, with an eye at the end through which the sutures can be threaded. A longitudinal incision 5 cm (2 in.) long is now made to expose the cuneiform, and the peroneal tendon is grasped after tunnelling subcutaneously towards its location in the subcutaneous tissue of the front of the ankle. The first two wounds are closed with fine catgut. The end of the tendon is quilted by a chromic catgut or linen suture and passed through an osteoperiosteal trap-door raised off the first cuneiform by a sharp osteotome, the foot being inverted. The sutures are passed so as to stitch the osteoperiosteal flap firmly into position over the tendon and thus obtain a strong, bony insertion for the transplanted tendon The skin wound is closed with fine catgut and a plaster bandage applied from the toes to just above the knee, with the foot at a right angle and in a position of varus. After six weeks the cast is bivalved to allow the foot to receive local treatment by massage, and active and passive movements. After each daily session for massage and re-education the cast is replaced and is worn for twelve weeks, after which a lateral iron and a medial T-strap are substituted, the medial side of the sole and heel of the boot being raised ¼ to ⅜ inch. This brace is worn for six months, and for three months the posterior section of the plaster is applied at night When the brace is discarded the patient should wear a 'crooked' or Thomas heel for a period of six months, and undue strain on the transplant must be avoided for one year.

Repair of Rupture of Tendons.—*Long Head of Biceps*—The disability following this injury is sometimes so slight that no operative repair is necessary Reattachment to the glenoid is usually impracticable, but the free end of the tendon may be passed through the short head and fixed to the coracoid In rupture in the lower part of the groove direct suture may be possible

Extensor Longus Pollicis—In recent injuries end-to-end suture

is usually possible. In old ruptures it may be possible to close the gap by tendon graft (palmaris longus) or by tendon transplantation from a neighbouring tendon (extensor carpi radialis brevis).

Rectus Femoris.—This usually occurs just above the patella and is best treated by sutures of fascia lata, as is rupture of the ligamentum patellae itself.

Tendo Calcaneus.—Considerable destruction usually occurs, and under such circumstances the site of union may be usefully reinforced by a living suture of fascia lata traversing the tendon well above and below the point of section. The foot is placed in the equinus position in a splint or plaster. Walking with an elevated heel is allowed at the end of a month.

Dislocation of the Peroneal Tendons.—Shallowness of the groove, abnormal laxity of the tendon mesentery, and shortening of the tendons have been suggested as possible factors favouring dislocation. In traumatic cases the tendons are exposed by incision, and any direct damage should be repaired. In recurrent cases the peroneal sheaths should be reefed and attached to the periosteum. It may be necessary to raise from the malleolus a periosteal flap with adjoining connective tissue These are reflected over the tendon and attached to the talus. The foot is maintained in eversion and plantar flexion for two weeks.

Tendon Lengthening.—*Tendo Calcaneus* —A vertical incision, about 15 cm. (6 in) long, is made on the medial side of the tendon from its calcanean insertion directly upwards The tendon is defined, and is then transfixed from side to side and split into anterior and posterior halves throughout its length. At the lower end the anterior half is detached from the calcaneus, and at the upper end the posterior half is cut across transversely. As the foot is brought into the right-angled position, the two halves of the tendon slide upon one another, and they are sutured in their new position with fine linen thread or chromic catgut The sheath is separately sutured over the tendon and the skin incision closed

Another method consists in exposing the tendon and splitting it longitudinally for a distance of about 5 cm. (2 in), and then cutting across the left half at its lower end and the right half at its upper end, so that the incision in the tendon is Z-shaped. If the cross-sections are bevelled better apposition is secured As the position of the foot is corrected the two segments slide on one another and they are sutured in their new position (Fig 57).

Bennett's Operation for Lengthening of the Quadriceps Muscle.—An incision is made on the anterior surface of the thigh from the middle of the patella upwards to the junction of the lower and middle thirds of the femur Parallel longitudinal incisions are then made to each

side of the rectus femoris to separate this muscle from the vastus medialis and vastus lateralis. A transverse incision then unites these incisions at the upper end. The tendon mass is further dissected from the underlying tissue until the tendon is completely detached. It is now possible to flex the knee fully. The incisions are then closed with catgut sutures (Fig 58).

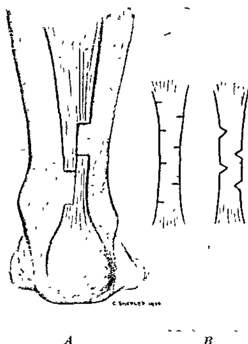


Fig. 57 *A* *Lengthening of Tendo Calcaneus.*
B Illustrates Method of Multiple Partial Division.

Myotomy for Congenital Torticollis.—Division of the sternomastoid for myogenic or congenital torticollis is performed by subcutaneous tenotomy or by the open method as soon as practicable after the wry-neck has been observed.

With the head extended and rotated so as to put the shortened muscle on the stretch, a transverse incision is made in the skin-fold above the clavicle, and is carried through the platysma to expose the fibrosed sternal and clavicular heads of the sternomastoid. The edges of the muscle are defined, a director is slipped beneath them to protect the internal jugular vein, and the muscle is divided on the director. It may be necessary to notch the deep cervical fascia before the deformity can be fully corrected After all haemorrhage has been arrested, a rubber-dam drain is placed in the dead space between the

cut ends of the muscle and is left in for forty-eight hours. In closing the wound everting sutures or clips are employed to overcome the tendency of the skin to become inverted.

If the patient has reached adult life, secondary shortening of the fasciae necessitates freer division, and it may even be necessary to divide the scaleni.

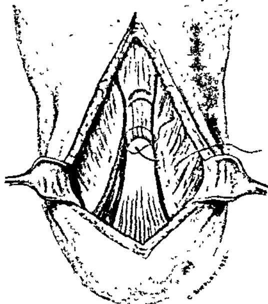


FIG. 58 Lengthening of Quadriceps Muscle by Bennett's Method.

In the child no after-treatment is required once the wound has healed, and in the course of a few weeks the deformity will completely disappear. The facial asymmetry diminishes gradually as the child grows In adults it may be necessary to apply a plaster cast or other apparatus to maintain the over-corrected position for a time.

The Operative Treatment of Infections of the Hand

The following principles are of the first importance in the management of infections of the hand (1) No effort should be spared to make an exact diagnosis of the condition present. (2) General anaesthesia is *essential* in the operative treatment of all but the most trivial infections. (3) A tourniquet on the arm is necessary in the treatment of certain cases, particularly tendon sheath and space

infections (4) Incisions must be carefully planned and must be adequate for efficient drainage.

Chemotherapy in the Treatment of Infections of the Hand.—*Prophylaxis.*—Many serious infections of the hand can probably be avoided by the prophylactic administration of chemotherapeutic drugs following minor or major injuries. Thus the oral administration of sulphanilamide or sulphathiazole given early in full doses for a few days may abort most streptococcal infections, while the systemic administration of penicillin in the earliest stage may abort most infections of the hand, including the many due to the staphylococcus.

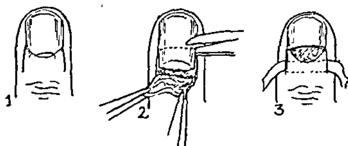


FIG 59. Operation for Paronychia
1 Incisions
2 Turning back flap and removing base of nail.
3 Replacing flap with drainage

Treatment—In all serious hand infections requiring surgical treatment, penicillin should be given in adequate dosage pre- and post-operatively This will help to prevent any extension of the infection as a result of the operation, and enable the surgeon to remove necrotic tissue more radically and with greater safety and so obtain quicker healing.

The Purulent Blister.—The whole of the raised epidermis must be carefully cut away, as the mere snipping of the blister may fail to stop the spread of the infection

Paronychia: Infection at the Nail-fold.—Operation is indicated when pus forms between the root of the nail and the nail bed and in cases where, in spite of careful conservative treatment, the infection persists. Two small incisions are made, each in line with the lateral nail sulcus and extending proximally for about 1 cm. (½ in.) (Fig. 59) The rectangular flap so outlined is dissected proximally off the nail root until the latter is fully exposed. One blade of a sharp-pointed scissors is then inserted under the edge of the nail well distal to the distal edge of the abscess under the nail, the nail is cut transversely across, and the proximal portion removed A small wick of vaseline gauze or a small slip of dental rubber is then

placed across the raw surface exposed by removal of the nail and the skin flap allowed to fall back into position over the drain. In the after-treatment fomentations are used for a few days only and then a spirit or vaseline dressing is applied. Prolonged use of fomentations predisposes to the production of exuberant granulations from the exposed nail bed which interfere with drainage and delay healing.

The Pulp Infection: Felon.—This infection owes its peculiarity to the anatomical structure of the pulp of the fingers. The tissues of the pulp are so arranged as to form what is virtually a closed connective-tissue space. This space includes the diaphysis of the phalanx and practically all the soft tissues of the pulp. Fibrous septa run from the deeper layer of the skin to the bone and subdivide the space into compartments in which lies fatty tissue and into which pass the sweat glands. The terminal portions of the digital arteries from which the soft tissue of the pulp and the diaphysis of the phalanx derive their blood-supply enter this space. As a result of this anatomical arrangement, infection within the closed space leads to a rapid rise of tension and consequent early necrosis of these tissues.

Immediate relief of tension is essential if early death of tissue is to be avoided; incision should therefore be made as soon as a definite pulp infection is diagnosed, and the incision must be such that it will divide the fibrous septa and so lay open the whole space. It should as a rule be carried out under general anaesthesia. A midline incision is to be avoided as it leaves a scar in the tactile portion of the finger, does not open up the space thoroughly, and if carried too far proximally is liable to open the tendon sheath, a structure which, in common with the joint, is not usually in danger from spread of infection from a focus in the pulp. The incision should therefore be towards the lateral side, the knife being inserted and passed across the pulp on the volar aspect of the phalanx and the incision extended throughout the whole length of the pulp it should not extend round the tip of the finger (Fig. 60) When treatment has been undertaken early no pus will be found, and with the relief of tension no necrosis will ensue and the infection will rapidly subside. Hot boracic fomentations for a few days, followed by a vaseline dressing, constitute the post-operative treatment.

In more advanced cases where tissue necrosis has occurred, healing will be delayed owing to the slow separation of the slough which results from the death of the soft tissue and of the partially or wholly necrotic diaphysis of the phalanx. In the latter case the necrotic diaphysis should be removed at the time of incision In this after-treatment, in addition to boracic fomentations, eusol injected into the wound with a small pipette will assist in the separation of the

slough and the bone sequestrum. When the soft tissue and bone have necrosed, the tip of the healed finger is left flat and contracted. When restoration of the pulp is important, it has been suggested that a free transplant of fat from the abdominal wall be used.

The Collar-stud Abscess: Distal Palmar Abscess.—In this common local infection of the hand pus forms either in the sub-epidermal or sub-dermal layers at the distal border of the palm between the base of two contiguous fingers, at which point the skin of the hand of a working man is hypertrophied and thickened. Infection as a rule enters through a small fissure in this thickened tissue, and the pus which forms fails to reach the surface through the thick overlying skin and therefore tends to pass dorsally into the fatty tissue of the web of the fingers, in which situation another collection



FIG 60. Operation for Pulp Infection, Lateral View, Cross-section, Anterior View.

of pus forms, often connected with the original focus only by a small communicating channel The important point in treatment is to be sure that both abscess cavities are adequately opened up. The incision is made on the palmar surface directly over the point of maximum tenderness. If the tissue of the web is found infected a dorsal incision is also made and through-and-through drainage established. The web may be completely cut if necessary without any disability ensuing.

Infection of the Dorsal Subcutaneous Space.—This space is an extensive area of loose subcutaneous tissue extending over the whole of the dorsum of the hand It may be infected by direct wounds penetrating the skin of the dorsum, or by extension of infection *from the dorsal aspects or from the webs of the fingers. Free incisions* made parallel with the metacarpal bones, and preferably towards the lateral limits of the infected area, with through-and-through drainage, are all that is necessary

The Tendon Sheath Infections.—(Fig. 61.) *Anatomy.*—An accurate knowledge of the anatomy is of the first importance in the diagnosis and treatment of these acute infections The digital sheaths extend from the level of the distal palmar creases to the insertion of the tendons into the bases of the terminal phalanges. Each synovial sheath is bound to the underlying phalanges by the fibrous flexor sheath. In the case of the index, middle, and ring fingers, the syno-

vial sheath ends blindly at its proximal end. The sheaths of the thumb and little finger are continued proximally into the palm, the sheath of the flexor pollicis longus continuing upwards as the radial bursa to a point about 2·5 cm. (1 in.) proximal to the flexion

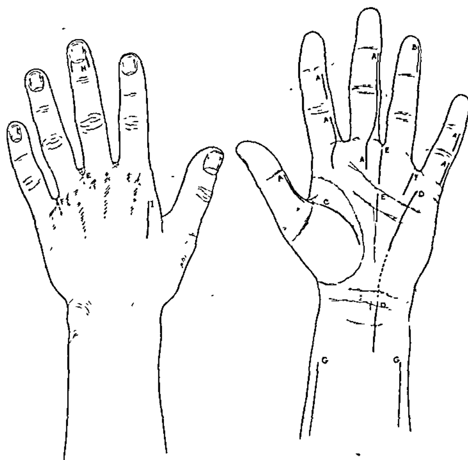


FIG. 61. Incisions.

crease at the wrist, while the sheath of the flexor tendon to the little finger continues upwards as the common palmar sheath or ulnar bursa to about the same level. This common palmar sheath envelops all the flexor tendons to the four fingers on their superficial, deep, and ulnar aspects, the main cavity of the sheath being on the deep aspect. The radial and ulnar bursae are in close

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pressure should be made over the site of this bursa in the palm. If pus can be expressed from it, it must be laid open by a further incision in the palm. This is made along the lateral border of the hypothenar eminence and extends from the distal flexion crease of the palm to the level of the distal border of the transverse carpal ligament. In the deepening of this incision two structures are liable to injury, viz. the branch of the ulnar nerve supplying the fourth and fifth fingers and, more proximally, the superficial palmar arch, both of which structures can be avoided in the bloodless field. The sheath is opened along its ulnar margin throughout the length of the incision. If pressure on the proximal end of this sheath above the wrist indicates the presence of pus, an incision is made as for opening Parona's space (p. 146)—or the palmar incision may be continued proximally to above the wrist in the line of the ulnar border of the sheath, opening the latter through its entire length. This incision must of necessity cut the transverse carpal ligament and is therefore not recommended.

The Radial Bursa.—This is almost invariably involved if the digital part of the flexor pollicis longus sheath is infected. The incision for opening the digital sheath is usually placed to the ulnar side of the thumb and may be extended proximally to open the radial bursa by skirting the base of the thenar eminence. It should not be continued, however, beyond a point 1 cm. (½ in.) from the distal border of the transverse carpal ligament, lest the motor branch of the median nerve which supplies the thenar muscles be endangered. The flexor pollicis longus lies nearer to the palm than is generally supposed, and the thenar muscles lie mostly to the radial side of the tendon. Should pressure on the proximal end of the sheath demonstrate infection there, an incision above the wrist as for draining Parona's space is indicated.

The Fascial Space Infections.—*Anatomy*—The fascial spaces are: A. *Palmar*: (1) the middle palmar space; (2) the thenar space; and (3) the deep fascial space of the lower forearm—*Parona's space.* B *Dorsal*: the dorsal sub-aponeurotic space.

The deep fascial spaces of the palm are potential spaces; and they lie deep to the flexor tendons and the lumbrical muscles, and superficial to the metacarpal bones and interossei muscles. These spaces do not extend beyond the distal palmar flexion creases and their proximal limit is the distal border of the transverse carpal ligament. The *middle palmar* space is limited on its medial side by a layer of fascia which separates it from the muscles of the hypothenar eminence. Its lateral limit is a layer of fascia which is attached dorsally in the line of the third metacarpal bone and passes forwards to the deep palmar fascia. The *thenar* space lies to the radial side of

relationship in the carpal tunnel, where the two sheaths frequently intercommunicate.

Surgical Treatment—The essentials for successful treatment are (1) early and accurate diagnosis, (2) deliberate exposure and free incision of the affected sheath, for which a general anaesthetic and a tourniquet must be used.

The Digital Sheath—The sheath should be opened in the first instance at the site of maximum tenderness which is usually over the proximal phalanx. The incision should be placed on the antero-lateral or lateral aspect and never in the midline and should extend throughout the length of the phalanx The skin is incised, then the rather dense fibro-fatty subcutaneous tissue, which by bulging into the wound may obscure the view to such an extent as to justify the removal of some of it Care must be taken to avoid injuring the digital artery and nerve which lie in the line of the incision. The fibrous sheath is now exposed and is incised close to its attachment to the phalanx. When this has been done, the distended synovial sheath (provided it has not already ruptured) bulges into the wound. It is then incised throughout the length of the skin incision. Purulent or sero-purulent fluid will escape Pressure is then exerted over the line of the sheath distal to the incision If, as a result of this pressure, more pus escapes through the incision in the sheath, another incision, similarly placed, is made over the middle phalanx and the sheath laid open at this level up to its distal termination Pressure is now exerted over the proximal end of the sheath, and if this leads to a further escape of pus through the original incision, the proximal end must be opened by a third incision This can be made directly over the sheath in the distal palm, extending from the flexion crease at the base of the finger proximally for about 2 cm ($\frac{3}{4}$ in), or this last incision may be made as a continuation of the original one In all cases the incision should open the sheath freely, but, as far as possible, incisions should not be carried across the flexion lines lest prolapse of the tendons occurs In most cases free incisions obviate the necessity for using any form of drain, the presence of which in, or in close proximity to, the tendon sheath is to be avoided as far as possible Sometimes it may be desirable to open the tendon sheath from both sides, in which case similar incisions should be made on the opposite side of the finger. Alternatively, in advanced infections, the two or three separate incisions may be joined to form one long incision, which thus runs the whole length of the sheath

The Common Palmar Sheath or Ulnar Bursa.—In infection of the little finger, careful pre-operative examination will probably have decided whether the infection has spread to the ulnar bursa, but in any case, after the digital sheath has been opened up,

The *dorsal sub-aponeurotic space* lies between the extensor tendons and the metacarpal bones and interossei muscles. When pus forms in this space drainage is established by incisions parallel to the tendons, and placed either medially and laterally to them or between them. Incisions should be of sufficient length to establish free drainage.

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the middle palmar space, being separated from it by the above-mentioned layer of fascia. Its dorsal wall is for the most part formed by the adductor pollicis transversus and the fascia covering it. Its anterior wall is part of the dense palmar fascia and, deep to this, are the flexor tendons of the index finger and the corresponding lumbrical muscle. Laterally the space extends to the radial border of the hand.

The *deep fascial space* of the lower forearm (*Parona's space*) is a potential space bounded dorsally by the lower ends of the radius and ulna and the overlying pronator quadratus muscle. On the volar aspect are the flexor profundus and flexor pollicis longus tendons with the termination of their respective sheaths. The radial and ulnar arteries and the ulnar nerve are anterior to the space. The space is closed laterally on either side by the union of the layers of fascia in the roof and floor.

Surgical Treatment.—The Middle Palmar and Thenar Spaces.—When pus collects in either of these spaces it tends to track along the line of one or other of the lumbrical muscles which, because of their origin from the profundus tendons, help to form the roof of these spaces. Drainage is therefore procured along the line of one of the lumbrical muscles In the case of the middle palmar space, incision should be made along any of the lumbrical canals that show signs of infection, i.e. along the lumbrical to the middle, ring, or little finger. If none shows evidence of infection the incision is made along the lumbrical going to the ring finger The incision starts at the web between the middle and ring fingers and extends into the palm to a point slightly distal to the distal palmar crease. The lumbrical canal is opened and a pair of sinus forceps passed along it, deep to the tendons and so into the space. A soft rubber dam drain is inserted

The *thenar space* is readily opened at its radial border by an incision made behind the web of the thumb, opposite the middle of the second metacarpal bone and on a level with its volar surface. A sinus forceps is passed in distally and medially along the palmar surface of the adductor transversus and deep to the flexor tendons of the index finger and a drain inserted

Parona's space is drained most efficiently through lateral incisions A free incision is made on the medial side of the forearm 5–7 cm. (2–3 in) above the ulnar styloid process and in a line with the volar aspect of the ulna The aponeurotic attachment of the flexor carpi ulnaris to the ulna is incised and a sinus forceps is passed across the forearm, keeping close to the bones, to the radial side where the point of the forceps is cut down on and through-and-through drainage established. A soft rubber drain is inserted.

joint through an elliptical incision on the dorsum carried round the corn. The toe is straightened, and the rawed surfaces are brought into contact with silkworm gut stitches which should be kept in place for about twelve days. Immobilization is secured for five or six weeks in an unpadded plaster case.

Hallux Valgus.—The appropriate operation depends on the etiology of the particular case and on the age and occupation of the

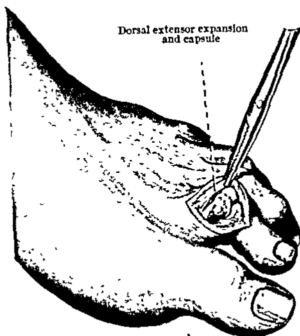


Fig. 62. Correction of Hammer-toe by Resection of the Head of the First Phalanx.

patient In *adolescents* there is an abnormal angle at the cuneiform-metatarsal joint which as the foot grows gradually pushes the toe into the valgus position. To secure normal alinement a wedge osteotomy of the cuneiform or of the metatarsal may be made through a longitudinal incision on the dorso-medial aspect of the foot, which avoids the sensory nerve and the dorsal vein. The medial collateral ligament is divided and turned medially, and the wedge of bone, with any exostosis that may be present, is removed Correct alinement having been secured, the ligament is repaired. In exceptional cases the displacement is so great that osteotomy of the neck of the metatarsal, or even wedge resection of the cuneiform, is necessary to secure correct alinement.

The *after-treatment* consists of immobilizing the foot in a padded cast for ten days. When stitches have been removed an unpadded

CHAPTER VIII

ORTHOPAEDIC OPERATIONS ON THE EXTREMITIES[1]

Operations on the Toes, Foot, Leg, Knee, and Hip Operations on the Hand, Wrist, Forearm, Elbow, and Shoulder.

Operations on the Foot

Infiltration anaesthesia, preceded by an injection of morphine or other general sedative, is sufficient for many operations on the toes and foot if performed for non-infective conditions. For active infective conditions a general anaesthetic is preferable.

Ingrowing Toe-nail.—It is essential to remove the nail along with its matrix. A longitudinal incision is made in the middle line of the nail down to the bone, and almost as far as the inter-phalangeal joint; this is joined by a horizontal incision, immediately distal to the joint, and carried transversely well to the affected side of the toe The flap of skin is dissected up, the nail is split longitudinally, and the affected half avulsed. The matrix is carefully removed with the knife and sharp spoon; the flap is then replaced and held in place by two or three sutures. The bed of the nail becomes covered with horny epidermis and soon ceases to be sensitive.

If the nail fold is tender and rolls over the nail margin in walking a wedge of the redundant tissue may be removed.

Subungual Exostosis.—An incision is made down to the bone parallel to and just beyond the edge of the nail, so that the soft parts and the nail can be raised in the form of a flap; the neck of the exostosis is divided. The flap is replaced and sutured.

Hammer-toe.—A longitudinal incision is made down to the bone on one dorso-lateral aspect of the toe, the extensor tendon is held aside and the head of the first phalanx, after being cleared, is protruded and removed with bone-forceps (Fig. 62) A corn or an inflamed bursa on the dorsum is removed by an elliptical incision carried round it

An alternative operation is to excise the proximal interphalangeal

with osteophytic formations which practically prevent movement of the joint. Sometimes there are small detached spurs of bone outside the joint. The chief complaint is of pain from pressure on the bursa and on the osteophytes. By excising these and if necessary fusing the joint the patient is relieved.

Metatarsalgia.—Manipulation of the metatarso-phalangeal and interphalangeal joint of the toes followed by immobilization of the foot in a plaster casing with the anterior arch supported by padding may prove of value. In some cases removal of the distal end of the affected metatarsal bone may be necessary, but is to be adopted only in severe cases which have resisted other forms of treatment. The condition may be associated with hammer-toe. In such cases operative relief of the hammer-toe followed by manipulation of the metatarso-phalangeal joint in flexion may be all that is required.

In some cases a small painful accessory bursa may be found beneath the head and neck of the metatarsal. In certain cases of metatarsalgia affecting the fourth metatarsal, the patient complains of darting neuralgic pain along the medial digital nerve. This may come on even when the patient is not bearing weight upon the foot. It has been successfully treated by resection of the most lateral branch of the medial plantar nerve through an incision made beneath the main arch of the foot on a line drawn between the head of the fourth metatarsal and the medial side of the heel.

In some cases the pain is due to pressure on a small neuroma on a digital nerve, and is relieved by excision of the nodule.

Pes Cavus or Claw-foot.—Early cases may be treated by manipulating the foot into a correct position with the aid of a Jones's wrench, and maintaining the corrected position by a plaster of Paris case. Sufficient force is used to stretch the contracted plantar fascia and the tendo calcaneus. When the foot has been mobilized so that a normal position is easily produced, the plaster case is applied and retained for three to six weeks. After its removal return to normal activity may be hastened by massage. Before walking is allowed a metatarsal bar about 1·25 cm. ($\frac{1}{2}$ in) thick is applied to the shoe, just behind the heads of the metatarsal bones This tends to prevent shortening of the plantar fascia. When there are specially tight bands of fascia which can be palpated when the forefoot is dorsiflexed, these should be tenotomized subcutaneously.

In more marked cases a small-bladed knife is entered on either the medial or the lateral surface of the heel and passed transversely across the foot between the skin and the fascia until it can be palpated on the other side The fascia is then divided throughout its whole breadth as near to its attachment to the calcaneus as possible, and the position of the foot corrected by manipulation or

walking-case is applied and worn for six or eight weeks till consolidation has taken place. This case should support the longitudinal arch of the foot and lift the metatarsal heads, but to allow of movement of the toes it should stop on the dorsal aspect at the level of the web.

In *acquired* cases there is usually an enlarged bursa over the joint, the articular cartilage is affected, and osteophytic outgrowths are present. In old people when there is little deformity and not much suffering, or when prolonged treatment is undesirable, it may be sufficient to excise the bursa and any overlying exostosis.

Keller Operation.—The incision exposes the first metatarso-phalangeal joint. The capsule is incised and the structures at the base of the phalanx dissected free. Enough of the base of the phalanx is removed with a Gigli saw to enable the distal portion to be placed in an over-corrected position. The exostosis on the head of the metatarsal is also removed, the cut being made obliquely upwards and laterally along the length of the metatarsal bone. The over-corrected position is maintained by means of a well-padded lateral splint, and after five days passive motion is begun.

Mayo Operation.—In middle-aged patients when there is well-marked painful arthritis, the head of the first metatarsal bone may be excised. A curved incision is made with the base downwards over the medial side of the metatarso-phalangeal joint, the skin being elevated as a flap which is separated from the bursa. A second incision with its base distal is now made round the bursa, leaving the base attached to the first phalanx. The head of the metatarsal bone is removed with heavy bone forceps and the cut end of the bone made as smooth as possible The bursal flap is turned into the joint in front of the bone, where it is held in place by one or two catgut sutures. The skin incision is sutured and a splint applied to hold the toe in slight flexion and adduction

Hallux Rigidus.—Operative treatment varies according to the state of the joint surfaces and the age of the patient

In young subjects when joint movement is relatively good, but there is contraction of the plantar fascia, particularly of its medial band, this may be divided just in front of its attachment to the calcaneus, with a small-bladed knife passed transversely across the sole from the medial side of the foot The toe is then dorsiflexed and held in this position by a plaster boot for two weeks

If a radiograph shows the presence of a ridge on the dorsal surface of the metatarsal, a straight dorso-medial incision is made over the joint, the tendon of the extensor hallucis longus retracted laterally, the capsule opened, and the ridge removed with an osteotome. If the base of the phalanx is eroded it should be removed.

In older patients the joint surfaces are frequently grossly distorted

Tenotomy of the Peroneal Tendons.—In the types of spastic flat foot in which there is much spasm of the peroneal muscles Jones advised tenotomy of the peronei, or, even better, that about 2·5 cm. (1 in.) of the tendon should be removed from the long and short peroneal muscles. The foot is then put up in plaster for three weeks, and the ordinary treatment begun thereafter. Naughton Dunn suggested crushing of the superficial peroneal nerves as an alternative to resection of the tendons.

Talo-navicular Arthrodesis.—The foot is thoroughly manipulated till it is flaccid and mobile. A 4-cm. (1½-in.) incision is then made, beginning in front of the medial malleolus and extending along the course of the tendon of the tibialis anterior. The tendon is retracted, and the talo-navicular joint exposed along its dorsal aspect by freeing the overlying ligaments and making strong flexion on the foot The joint is denuded of ligaments, and its capsule opened. A curved gouge is used to excise the articular surfaces of the talus and the navicular, care being taken to preserve the ovoid shape of the head of the talus and the concavity of the navicular, so that when the forefoot is again adducted to its proper corrected position, the navicular will rotate and remain in contact with the denuded head of the talus. In some cases, in addition to this arthrodesis, a wedge of bone may be removed from the navicular and inserted through an incision on the lateral side of the foot into a bed prepared for its reception in the antero-lateral part of the calcaneus. In most cases the foot is put up in plaster in the corrected position for six weeks.

Occasionally local arthritic changes in the naviculo-cuneiform and adjacent joints make it advisable to secure fixation of the affected joints by erasion of the articular surfaces or by the insertion of a graft taken from the tibia.

Congenital Talipes Equino-varus.—Open operation for correction of congenital club-foot is not often required if conservative measures have been thoroughly employed.

Brockman advises that an incision be made on the lateral side of the foot over the calcaneus, through which the attachments of the plantar muscles and fascia are detached as far backwards and medially as possible. A second incision is then made on the medial side of the foot, and the remaining attachments of these muscles are completely detached from their origin The origins of the abductor hallucis are dissected off. This can be accomplished with safety, provided it is realized that in a congenital club-foot the vessels do not pass into the foot in a curve as commonly figured in text-books of anatomy. In this deformity the branches of the posterior tibial artery pass straight down till they reach the medial side of the foot, when they turn suddenly and enter the sole almost at a right angle.

by wrenching. The corrected position is maintained in a plaster cast for three or four weeks.

In cases of a moderately severe degree, Steindler's operation of stripping the calcaneus may be used. After a tourniquet has been applied to the thigh a horizontal incision is made over the medial aspect of the calcaneus, reaching to a point 5 cm. (2 in.) anterior to the medial tubercle of the bone. After the skin has been divided, the plantar surface of the plantar fascia is separated from the subcutaneous layer of fat. The fascia is then incised transversely, close to the point where it blends with the lower surface of the calcaneus The muscles inserted into the lower surface of the calcaneus are then stripped off the periosteum with a blunt instrument, as far forwards as the calcaneo-cuboid joint in order to reach a slip of the long plantar ligament which extends between the calcaneus and the cuboid. This ligament is usually considerably contracted No danger to the plantar vessels and nerves need be apprehended, since the stripping is done close to the bone. The foot is held in the corrected position with the wrench while tenotomy of the extensor and flexor tendons is carried out and the plaster case is applied.

Many variants and additions to these operations have been used to meet special indications: among them division or transplantation of tendons in the sole, division of a shortened tendo calcaneus, open division of the fascia or of the plantar ligaments, and wedge resection of tarsal bones The technical details of these are beyond the scope of this section.

Flat Foot.—*Manipulation* —As the first requisite in the treatment of weak or flat foot is to have the foot quite mobile and free from any spasticity or rigidity, it is necessary in treating the rigid type to secure this mobility by means of manipulation. When the patient is anaesthetized, a good deal of the restriction of movement will be found to have been due to muscle spasm. If any further restriction of movement remains, the foot is forcibly manipulated with a Thomas's wrench, until it is flexible and flaccid The foot is forced first downwards, then medially and upwards into extreme varus, and an attempt is made to get the lateral border of the inverted foot up to a right angle with the leg The arch is thus completely restored, and a plaster case is applied from the toes to the tibial tubercle, with the foot in the position of talipes equino-varus. Walking should be begun, since the full weight of the body tends to overcome the deformity, and to create a habit of walking in this corrected position. The plaster is left on for four to six weeks, and the patient is then fitted with a supporting brace, usually of the Whitman type. Strapping with adhesive plaster is employed, and continued as long as there is any tendency to valgus deformity.

attained, a plastic operation on bone may have to be considered. In the past, the operations which have found most favour have been wedge tarsectomy and talectomy. Besides these, excision of the head of the talus, removal of the cuboid, and removal of part of the calcaneus have also been advised. In late cases when full bone growth has been attained, the ideal operation for the correction of congenital club-foot is arthrodesis of the talo-calcaneo-navicular, the calcaneo-cuboid, and the posterior talo-calcanean joints, with the removal of a sufficient amount of bone to enable the deformity to be wholly corrected.

In some cases, even after adequate treatment of the deformed foot, an unsightly 'in-toed' gait may be present owing to a marked degree of medial torsion of the shaft of the tibia. Fracture of the tibia with an osteoclast will allow of over-correction, with subsequent fixation in plaster. If osteotomy of the tibia is performed, the line of division should be oblique rather than transverse, to facilitate the contact of the fragments when subsequently fixed in plaster.

Stabilizing Operations on the Foot.—A foot which is unstable from paralysis, or physiologically useless from deformity, may be greatly improved by an operation having for its purpose the production of stability. Such operations, since they produce stability, may also cure deformity, even though at the same time they reduce to a considerable extent movement at the joints A stabilizing operation does not necessarily mean an arthrodesing operation, but merely the formation of fibrous union between contiguous bones.

Paralysis of the muscles acting on the ankle-joint, either from poliomyelitis or from nerve injury, is the commonest indication for a stabilizing operation. To ensure a useful foot, tendon transplantations may be combined with stabilization. In considering the feasibility of performing a stabilizing operation on the foot, the state of the knee-joint and of the hip-joint must be taken into consideration. If there is a flail knee-joint, for example, it is questionable whether a satisfactory result will be obtained by stabilizing the ankle-joint.

Whitman's operation of *talectomy* may be carried out in various paralytic conditions which result in calcaneo-varus, calcaneo-valgus, and even in paralytic club-foot It is also indicated in traumatic conditions such as ununited fracture of the talus.

A tourniquet is applied to the thigh The incision starts just behind, and about 2·5 cm (1 in) above, the lateral malleolus, and runs downwards behind the fibula, forwards 2 cm. (¾ in.) below the malleolus, and then in a curve over the dorsum of the foot to the prominence of the navicular. The peroneal tendons are exposed, and divided or retracted. The lateral collateral ligament and the

The tendon of the tibialis posterior is then identified. There should be no difficulty in opening its sheath if it is borne in mind that the tendon lies well to the front as it passes to the navicular. By noting the direction taken by the flexor digitorum longus, the mistake of opening the sheath of this tendon will be avoided. Having traced the tibialis posterior to the navicular, the decision whether to divide it or not will depend entirely upon its contraction. If it is preventing the joint from being identified, it is detached from the tubercle of the navicular, and if necessary its accessory attachments to the other bones of the tarsus are divided.

The next step is to dissect the structures off the inferior surface of the tarsal bones, until the whole of the anterior and medial surfaces of the navicular and the medial aspect of the sustentaculum are exposed. The forefoot is now moved so as to identify if possible the position where the navicular abuts on the calcaneus. All the ligaments on the medial and inferior aspects of this joint, and if necessary part of the superior talo-navicular ligament, must then be divided. When this has been done, the foot is abducted and dorsiflexed. The navicular then alters its position and comes to lie in front of the head of the talus, and the anterior portion of the calcaneus moves laterally from beneath the talus. For this operation to be successful it is necessary to be able to hold the foot corrected without having to use any force. If it cannot be so held, there is still some obstacle to be removed.

At this stage the medial, inferior, and part of the anterior surface of the head of the talus should be visible, and there is a space between the sustentaculum and the navicular. The incisions are then closed and plaster applied, but not with full correction, as this may result in interference with the circulation.

At the end of a fortnight the plaster is removed, and, without removing the stitches, the foot is manipulated into the fully corrected position. If the stitches are removed before this is done, there is a risk that the incision will split open. Should any true equinus at the ankle-joint remain, as usually happens, the tendo calcaneus is elongated. A close-fitting plaster is then applied, and in a few days the child is allowed to walk.

Six to eight weeks later the plaster is removed. Ordinary boots are supplied, and a club-foot shoe for wearing at night. A long course of exercises is subsequently given to teach the child how to evert its feet voluntarily, and especially to increase the power of the extensor digitorum longus muscle. By this operation it is possible to correct the troublesome feature of congenital club-foot—namely, the inversion of the heel.

Tarsectomy.—In neglected cases when full growth has been

attained, a plastic operation on bone may have to be considered. In the past, the operations which have found most favour have been wedge tarsectomy and talectomy. Besides these, excision of the head of the talus, removal of the cuboid, and removal of part of the calcaneus have also been advised. In late cases when full bone growth has been attained, the ideal operation for the correction of congenital club-foot is arthrodesis of the talo-calcaneo-navicular, the calcaneo-cuboid, and the posterior talo-calcanean joints, with the removal of a sufficient amount of bone to enable the deformity to be wholly corrected.

In some cases, even after adequate treatment of the deformed foot, an unsightly 'in-toed' gait may be present owing to a marked degree of medial torsion of the shaft of the tibia. Fracture of the tibia with an osteoclast will allow of over-correction, with subsequent fixation in plaster. *If osteotomy of the tibia is performed, the line of division* should be oblique rather than transverse, to facilitate the contact of the fragments when subsequently fixed in plaster.

Stabilizing Operations on the Foot.—A foot which is unstable from paralysis, or physiologically useless from deformity, may be greatly improved by an operation having for its purpose the production of stability Such operations, since they produce stability, may also cure deformity, even though at the same time they reduce to a considerable extent movement at the joints. A stabilizing operation does not necessarily mean an arthrodesing operation, but merely the formation of fibrous union between contiguous bones.

Paralysis of the muscles acting on the ankle-joint, either from poliomyelitis or from nerve injury, is the commonest indication for a stabilizing operation. To ensure a useful foot, tendon transplantations may be combined with stabilization. In considering the feasibility of performing a stabilizing operation on the foot, the state of the knee-joint and of the hip-joint must be taken into consideration If there is a flail knee-joint, for example, it is questionable whether a satisfactory result will be obtained by stabilizing the ankle-joint

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Tarsectomy—In neglected cases when full growth has been

(p. 119). The foot can now be displaced backwards and the head of the talus allowed to rest upon the cuneiform bones, while the bodies of the cuboid and the calcaneus also come into apposition. The extensor brevis is now replaced and the wound closed. A greater mass of bone is removed on the medial side than on the lateral side. The arch of the foot is more symmetrical as regards its antero-posterior halves, and the weight-bearing centre is fixed at the summit of the arch.

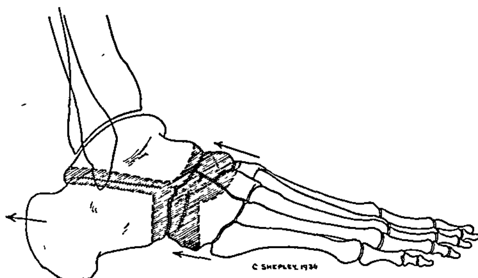


FIG 63. Operation for Stabilization of the Foot by Naughton Dunn's Method.

In certain cases where there is a marked equinus deformity the tendo calcaneus may also be lengthened The foot is put up in a plaster case for three months. In cases in which there is loss of power in the calf muscles, arthrodesis of the ankle-joint may also be done.

The extra-articular check operation of Campbell differs from the extra-articular arthrodesis practised in tuberculous conditions in that the motion of the joint is not quite obliterated, but is merely checked by the construction of artificial bone-blocks. The operation is carried out in cases of paralytic drop foot, and may be combined with a sub-taloid arthrodesis (Fig. 64).

An incision is made from the antero-lateral surface of the ankle, 2·5 cm. (1 in.) above the joint, passing down the dorsum of the foot to the lateral cuneiform. The bones are exposed by reflecting the ligaments medially and laterally, and good access is thus obtained to the entire tarsal region A small portion of the head of the talus, the whole of the navicular, and the articular cartilages from the posterior surfaces of the cuneiforms are resected A second incision is now made over the tendo calcaneus and the tendon is lengthened,

interosseous ligaments are then divided. Starting from the body, and proceeding to the head and neck of the talus, the bone is dissected out from beneath the extensor tendons. Afterwards the foot is forcibly wrenched medially so that the whole ankle-joint is opened up. The head and neck of the talus may now be freed until the entire bone is completely separated from its ligamentous attachments, and removed. The articular aspects of the two malleoli are then denuded of cartilage, and a new site for their articulation made nearer the front of the foot. To do this, a thin section of bone is cut from the lateral aspect of the calcaneus and cuboid, and the soft tissues, along with a thin section of bone, are stripped off from the medial aspect of the navicular. The foot is now displaced backwards at least 2·5 cm (1 in), the raw surfaces of the malleoli being adapted to the junction of the calcaneus and the cuboid on the lateral side, and to a point directly behind the navicular on the medial side of the foot. This is the most important part of the operation it brings the weight of the body over the highest part of the arch of the foot. The anterior surface of the tibia now lies above the level of the mid-tarsal joint, and the heel protrudes backwards. The wound is closed after re-uniting the peroneal tendons.

The foot is now put up in a position of plantar flexion and slight valgus, the plaster case reaching to above the flexed knee. To prevent oedema, the knee is suspended from a cage when the patient is returned to bed After ten days the patient is allowed up in the plaster case, which is retained for about three months. During this time the case may be changed to verify, and correct if necessary, the position of the foot After removal of the plaster the patient should be able to wear an ordinary boot, but this may require a little padding over the now-prominent heel.

Naughton Dunn's operation (Fig. 63) combines with sub-taloid arthrodesis a reconstruction of the forefoot, the latter being shortened and a degree of symmetry between the two halves of the longitudinal arch established, to improve weight-bearing.

An incision is made from the lateral malleolus to the base of the fifth metatarsal The extensor digitorum brevis is exposed and its origin from the head of the calcaneus detached The other extensor tendons are elevated from the dorsum and the bones exposed. The reshaping of the foot is done as follows: the adjacent surfaces of the calcaneus and the cuboid are removed, as well as the head of the talus, the whole of the navicular and the proximal cartilaginous surfaces of the cuneiform bones A cup-shaped depression is made in the head of the talus. The ligaments between the talus and calcaneus are then divided, and the two bones separated with a gouge. The adjoining surfaces are then resected as in a sub-taloid arthrodesis

injuries at the ankle-joint, the incision is made over the projecting part of the bone. In club-foot also the bone projects on the dorso-lateral aspect, and is cut down upon over its most prominent part.

In tuberculous disease the bone may be removed by a longitudinal incision, which begins on the anterior aspect of the fibula, a hand's breadth above the ankle-joint, and extends downwards over the lateral surface of the talus to the base of the fifth metatarsal bone. The incision enters the ankle and mid-tarsal joints and exposes the head and the body of the talus. The capsule of the joint must be thoroughly separated from the neck of the bone, and the next important step is the severance of the strong interosseous talo-calcanean ligament. The remaining ligamentous connexions having been divided and the foot forcibly inverted, the bone is cleared and delivered.

Excision of the Calcaneus.—For sarcoma the entire bone must be removed with its periosteum. The incision recommended by Farabœuf begins at the base of the fifth metatarsal bone, and is carried horizontally backwards just above the border of the sole, passing round the posterior aspect of the heel to the posterior part of the greater tuberosity of the calcaneus. A vertical incision, parallel to and a little in front of the tendo calcaneus, meets the horizontal one on the medial aspect of the heel.

Landerer recommended a medial longitudinal incision extending from the tendo calcaneus, over the heel, into the sole of the foot. Through this incision not only the calcaneus, but, if necessary, the other bones of the tarsus can be removed.

Operation for Spur on Calcaneus.—A semilunar incision is made posteriorly distal to the insertion of the tendo calcaneus. The flap is dissected down, the spur exposed at the origin of the plantar fascia, and the spur and underlying bone removed by means of a gouge or chisel. Cancellous bone which remains is pressed down by a smooth instrument to lessen callus formation.

Operations on the Leg

Complications and sequels of *Pott's fracture* may call for surgical treatment. *Non-union* of one or other malleolus, or of a posterior marginal fracture of the tibia, may be dealt with by exposing the fragments, freshening the surfaces, and pegging them in position.

Mal-united fracture may be corrected by an osteotomy just above the malleoli extending through both bones. This is best accomplished through two incisions, one over the lower extremity of the fibula, and one over the lower extremity of the tibia. In cases of extreme eversion of the foot, a wedge of bone, base inwards, must be removed from the tibia Care must be taken that the transverse line of the

the two flaps being reflected downwards and upwards. The space between the tendon and the tibia is now cleared of loose tissue, and, with a periosteum elevator, the postérior surface of the tibia is cleared, as well as the upper surface of the calcaneus. The foot is now dorsiflexed and the posterior edge of the body of the talus is removed. A wedge-shaped cavity is then chiselled out of the calcaneus just below the posterior extremity of the talus, and into

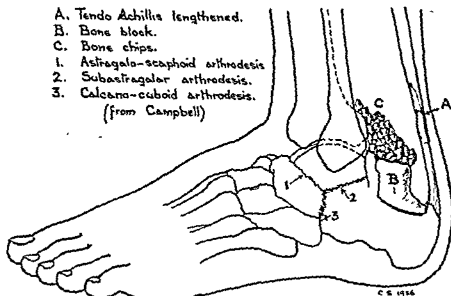


Fig. 64. Extra-articular Check Operation for Stabilization of Foot by Campbell's Method.

this cavity the denuded navicular and the small pieces of bone obtained in the first incision are placed and piled into a pyramidal mass which rises well above the posterior edge of the ankle-joint. The tendo calcaneus is united and the wound closed The foot is now immobilized in plaster for at least eight weeks, at a right angle or in slight plantar flexion, thereafter a strong boot with a lengthened upper should be worn.

Excision of Individual Bones.—A *metatarsal* bone may be excised for tuberculous osteomyelitis. The incision is on the dorsum, parallel to the long extensor tendon, the metatarso-phalangeal joint is opened, and the head of the bone is cleared and raised, so as to strip the bone from the soft parts from before backwards. If the head of the bone is free from disease, it may be preserved and, instead of disarticulating, the neck of the bone is divided with an osteotome or Gigli saw.

Excision of the Talus.—When removal of the talus is called for in

checked by X-ray later, and any further correction [illegible] two weeks. As a rule [illegible] need not be used.

De-rotation Osteotomy of Tibia.—In a few cases of congenital talipes, even after the foot has been satisfactorily corrected, an abnormal medial rotation of the tibia persists and causes inturning of the toes. To correct this, the tibia is exposed over its middle third, the periosteum stripped off its anterior surface, and a row of fine holes drilled obliquely across the bone, penetrating both the anterior and posterior cortex. The holes are joined up by an osteotome or motor saw and the tibia swung into position. The foot, knee, and thigh are encased in a padded plaster for three weeks, after which the patient moves about with crutches.

Operations for Inequality of the Lower Limbs.—To obviate the lameness which inevitably results from any considerable degree of shortening of one limb, an attempt may be made to equalize the length of the limbs in one of several ways: (1) by premature fusion of one of the epiphyses of the longer limb (lower femoral, or upper tibial); (2) by removing a segment of bone from the longer limb (usually from the femur); or (3) by lengthening the shorter limb.

Opinions differ as to the relative merits of these procedures, the majority favouring the removal of a segment of bone from the longer limb. The operation is carried out through a lateral incision, and two parallel oblique osteotomies are performed. They are made oblique so that after removal of the section of bone, which is approximately equal to the difference in length of the two limbs, the two femoral fragments may be united with a Parham band. After the wound is closed, the leg is retained in a plaster spica extending from the waist to the toes of the affected side for a period of two to three months.

If it is desired to retain the stature of the patient, an operation designed to lengthen the shorter limb may be performed. The operation on the lines of that devised by Abbott is carried out on the femur, which is approached by a long vertical incision on the lateral side, and a Z-shaped osteotomy is done, on the same lines as in the operation for lengthening of the tendo calcaneus (p. 137). After the wound is closed, the condyles of the femur are transfixed horizontally by a pin, and the trochanter antero-posteriorly by another. A plaster case is now applied extending from the waist to the toes on the affected side and incorporating the pins. After it has set, it is cut circularly at the level of the femoral section. There is now a body plaster and a leg plaster, the only attachment of which is through the soft tissues of the limb. Across the gap between the two plasters is now fixed a screw apparatus, the screwing up of which causes a separation of the two plasters and thus lengthens the limb. It has been found that a limb may be lengthened by 5 cm. (2 in.) or more

joint is preserved. The tendo calcaneus is frequently contracted and may have to be elongated through a separate incision. A plaster casing is applied for a month.

In *old-standing* cases arthritic changes interfere with reconstructive operations, and the best results are obtained by arthrodesis (p. 119), the ankle being fused in a position of 5 degrees to 10 degrees plantar flexion to allow for natural walking in a shoe with a heel.

Traumatic club-foot following epiphyseal injury is dealt with by inserting a bone wedge into the tibia, the size and disposition of which are calculated from X-ray tracings of the deformed joint. If necessary the wedge is supplemented by bone chips from the divided fibula. A plaster case controlling the ankle and knee is worn, and crutches are used until sound consolidation has taken place; thereafter an iron support for the ankle is used for at least six months.

Deformities due to Rickets.—Gross rachitic deformities are less common now than they were, but there are still cases of 'bow-legs' which either fail to respond to treatment by splinting and relief from weight-bearing, or which are not brought for treatment until the bones are too consolidated for correction to be obtained by any method other than operation.

Multiple Drilling and Osteoclasis is the method of choice. It ensures fracturing the bones at the exact level desired, and avoids a disfiguring scar. The risk of non- or delayed union is slight.

The site of maximum curvature is selected by X-ray examination or by simply placing the knees in contact and marking the spot where the legs cross each other. A trocar and cannula $\frac{3}{16}$ in. or $\frac{5}{32}$ in. in diameter is passed through a small incision made in the skin over the medial surface of the tibia. The cannula is pushed in until it impinges on the tibia, then the trocar is withdrawn. A drill is passed down the cannula and a hole is drilled through the tibia penetrating both medial and lateral cortex. It is then withdrawn from the lateral but not from the medial side, and moved to a slightly different angle. This is repeated until the lateral cortex has been weakened by a series of holes, the cannula protecting the soft tissues from injury by the drill. The drill is then withdrawn and the leg is laid across a wooden wedge wrapped in a sterile towel. The limb is grasped firmly above and below the drilled area, and by a sudden downward movement the tibia is fractured at this site. In most cases it is better to fracture the fibula also by continuing the pressure over the wedge until it is felt to snap.

The limb is firmly bandaged over wool padding and held in a corrective plaster carried as high up the thigh as possible. When moulding the limb in plaster, what would appear to be considerable over-correction is necessary in order to obtain the correct line. This is

In extreme cases of knock-knee in which there is a tendency to lateral dislocation of the patella, this must be prevented by over-correction of the deformity in the direction of genu varum.

In children with fat limbs there is a tendency for the osteotome to slip, and to obviate this, through an incision on the lateral aspect a series of holes are drilled in the femur in V-shape with the apex of the

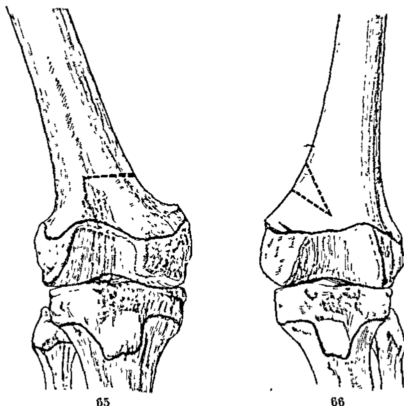


FIG 65. Linear Osteotomy for Knock-knee by Macewen's Method.
Site of division indicated by dotted line, the epiphyses indicated by continuous dark lines

FIG. 66 Cuneiform Osteotomy for Knock-knee
The epiphyses are indicated by continuous dark lines.

V pointing distally just proximal to the epiphyseal plate These holes are joined with an osteotome, and the bone is fractured (Stirling)

In the rare cases in which the deformity is chiefly due to obliquity of the tibia, it may be necessary to remove a wedge from the tibia with its base on the medial aspect; this is done through a horizontal or semi-lunar incision on the medial aspect of the limb.

Genu Varum.—This deformity is best corrected by removing a wedge of bone from the lateral aspect of the femur, the incision passing through the ilio-tibial band and vastus lateralis muscle. In

by such a method. It takes a considerable time, however, probably about a month, before the full length can be achieved, a few turns of the screw being taken up every day. When the maximum amount of lengthening is produced, a few turns of a plaster bandage will fix the two segments of plaster and the limb can then be treated as a recent fracture.

Deformities of the Knee.—Various deformities result from irregularities in the growth of the epiphyses in the vicinity of the knee, e g. tibia vara, tibia valga, genu recurvatum, which are treated by appropriate osteotomies, with subsequent immobilization in plaster.

Osteotomy for Knock-knee and Bow-knee.—Macewen's classical operation for knock-knee consists in a linear osteotomy of the femur above the condyles. The limb is laid on its lateral side upon a sandbag; at a point where two lines meet—one a finger's breadth above the patella, the other a finger's breadth in front of the tendon of the adductor magnus—the knife is introduced in the long axis of the limb and made to cut directly upon the bone through the substance of the vastus medialis. The incision is just long enough to admit the largest osteotome, which is then passed along the knife down to the bone, and turned so that its edge is at right angles to the long axis of the femur (Fig. 65) The osteotome is grasped with the left hand, the ulnar border of which rests on the limb, and is driven through the bone by successive blows of the hammer, the osteotome being slightly withdrawn or rocked laterally between the strokes so as to prevent its becoming jammed. After the cortex has been divided through fully half the circumference of the bone, a finer and narrower osteotome is passed along the face of the first and substituted for it, and the division continued until at least three-quarters of the thickness of the bone is cut through, after which the osteotome is withdrawn. The wound is then covered with gauze, and while one hand grasps the thigh at the level of the wound, the other grasps the leg about its middle and forcibly abducts the latter until the femur breaks across with an audible snap, after which, with a little manipulation, the deformity is easily rectified. There is some oozing of blood from the bone marrow, but it soon stops The wound is sutured and the limb is put up in a plaster case

The same operation may be performed from the lateral side with equally satisfactory results

After two months the plaster is removed, but the child is kept in bed although encouraged to kick his legs about and use his muscles In about three months he can go free The knee is a little unstable for some time owing to laxity of the collateral ligaments and wasting of the quadriceps, but these recover under massage and systematic exercises.

tendon; and below, the incision is carried through the capsule at the medial border of the ligamentum patellae. The synovial membrane is divided in the same line. The patella is then dislocated to the lateral side of the joint, and, on flexing the knee, an excellent view is obtained of the whole of the anterior compartment. If symptoms point to the loose body being to the lateral side of the joint, the position of the skin and capsule incisions are reversed. The body or bodies having been removed, usually after flexing the knee fully, the tissues are brought together in layers, and abundant dressings and a splint are applied.

If the bodies are located in the back of the joint and are too numerous or too large to pass to the front, a popliteal incision may be employed. A linear incision 10 cm. (4 in.) long is made in the popliteal space centred over the joint line and slightly medial to the median line. The vessels are retracted laterally and the body felt by palpation.

If the joint is to be entered laterally, an incision along the anterior edge of the biceps with the knee extended may be made. The knee is then flexed, allowing the biceps to be retracted and the ilio-tibial band to be divided sufficiently to expose the capsule. The capsule is opened either above or below the popliteal tendon. A medial and posterior incision may be employed following the anterior border of the sartorius down to the capsule, the capsule being opened behind the main part of the medial collateral ligament.

Removal of the Medial Semilunar Meniscus.—In the majority of cases the lesion involves the anterior end of the medial meniscus, and the joint is opened in the interval between the ligamentum patellae and the tibial collateral ligament. The skin of the entire limb receives a two-day preparation Sterile mackintoshes and sheets are placed over the patient's body and beneath the limb, and a tourniquet is applied well up the thigh over a sterile towel. The knee is flexed over a sand-bag and made to hang over the end of the table, the leg and foot being enveloped in a sterile sheet. The area of operation is then encased in gauze wrung out of spirit.

The surgeon puts on two pairs of gloves and seats himself on a low stool facing the joint.

The skin incision begins about 2·5 cm. (1 in.) from the medial aspect of the middle of the patella, passes straight downwards parallel to the lower half of the patella and the patellar tendon for 10 cm (4 in) to just below the articular surface of the tibia, when it is curved backwards for 2·5 cm. (1 in.), stopping short of the medial collateral ligament (Fig 68B).

Fisher's incision begins at the point of the medial condyle parallel to the upper border of the patella just anterior to the femoral attachment

extreme cases it may be necessary also to remove a wedge from the lateral aspect of the tibia below the epiphyseal line. The tibia is exposed by a vertical or semi-lunar incision

Combinations of knock- or bow-knee with curvature of the shafts of the femur and tibia may call for multiple division of the bones.

Osteotomy for Bow-leg.—The incision is made on the subcutaneous aspect of the tibia and is only large enough to admit the osteotome, the cortical bone of the medial and lateral surfaces, and especially of the dense anterior border, is divided; the posterior layer of cortical bone is broken by manual force. The fibula is also forcibly bent or broken; *failing this, it may be divided with a narrow osteotome.*

If a single linear osteotomy fails to straighten the leg, it should be repeated at whatever places may be required

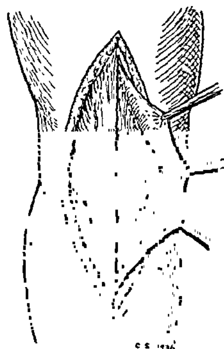


Fig. 67. Exposure of Knee-joint by Timbrell Fisher's Patella-displacing Method

Arthrotomy for Removal of Loose Bodies.—If the loose body can be localized by X-rays, or if it can be felt and held in an accessible position, it may be transfixed with a sharp needle and cut down upon directly. The small incision in the capsule and synovial membrane is closed with a fine suture, and a firm supporting dressing applied.

When the body cannot be accurately located and fixed near the surface, a patella-displacing operation, as recommended by Timbrell Fisher, is suitable (Fig 67) A slightly curved incision is made through the skin and subcutaneous tissue, commencing above in the midline 2·5 cm (1 in) above the uppermost limits of the suprapatellar pouch, skirting the medial border of the patella and its ligament, and ending slightly to the medial side of the tubercle of the tibia. The flap of skin and subcutaneous tissues is reflected laterally to slightly beyond the lateral border of the patella The layer of fascia covering the quadriceps tendon is divided in the midline and reflected Next, the capsule is divided 0·6 cm. (¼ in.) from and parallel to the medial border of the patella. The incision is carried upwards somewhat obliquely to the medial fibres of the quadriceps

technique of removal of the cartilage should be a purely instrumental one, including the sewing of the synovial layer and capsular ligament, which are separately sutured with catgut. Gauze dressings are applied, then large rolls of sterile cotton-wool extending from the ankle to the top of the thigh, and the limb is bandaged firmly enough to exert through the cotton-wool enough elastic pressure to control haemorrhage and effusion into the joint. The tourniquet is then removed: the object of placing it high up on the limb is to secure firm pressure of the bandage before it is taken off. No splints are required. Stitches should be removed in ten days.

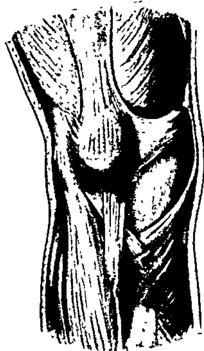


Fig 69. Goldthwait's Operation for Recurrent Dislocation of Patella.

The post-operative treatment consists in re-educating the quadriceps apparatus by systematic rehabilitating exercises until the patient is able to resume light occupation, usually in about six or eight weeks.

Recurrent Dislocation of the Patella.—The *Goldthwait Operation* (Fig. 69) consists of an incision over the patellar tendon extending 2·5 cm. (1 in) below its insertion. The tendon is split longitudinally and the lateral half detached and passed under the medial half to be inserted into the medial aspect of the tibia, if possible into the insertion of the sartorius tendon The operation may be amplified by a transplantation of the semitendinosus tendon forward to attach it as nearly as possible to the patellar tendon.

Albee Operation —A semilunar skin incision is made at the lateral border of the patella, sufficiently long to reach below the tibial tuberosity The lateral condyle is exposed, and with a broad chisel an incision 5 cm (2 in) long is made into it in the frontal plane about 5 cm (2 in) behind the anterior aspect of the articular surface. By prising the portion of the lateral condyle in front of the osteotome upwards, the fragment is elevated. The gap in the bone is filled by an autogenous transplant from the tibia (Fig. 70).

Various modifications and amplifications of these procedures are employed to meet varying conditions. The knee is fixed in the extended position for about six weeks.

of the medial collateral ligament, after which it is curved downwards and forwards with the convexity below, terminating just medial to the patellar tendon about 2·5 cm. (1 in.) below the patella (Fig. 68A).

The skin and fascia having been divided, the gauze is fixed to the skin by Michel clips. The surgeon then removes one pair of gloves, and, using a fresh knife and forceps, opens the capsule and synovial membrane above and over the anterior end of the meniscus. Retractors are now inserted and the condition of the meniscus is investigated.

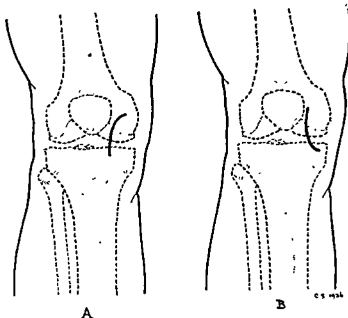


FIG 68 Incisions for Exposing the Medial Meniscus.
A Timbrell Fisher's Incision
B Sir Robert Jones's Incision

If the anterior end is not displaced, it is divided with a sharp knife so that it may be freed, and grasped with strong, blunt forceps. In doing this the infrapatellar pad of fat should not be injured, otherwise a painful condition may develop later behind the patella from organization of effused blood By pulling upon the forceps towards the midline of the joint and by abducting and laterally rotating the leg upon the femur, the coronary or suspensory ligament of the cartilage binding it to the medial collateral ligament can be easily divided with a short, strong knife, and as much of the cartilage as possible is removed A curved knife is useful for this purpose. It is difficult to remove the whole of the meniscus by an anterior incision, and, if it is thought that the posterior horn of the cartilage may be responsible for the disability, then it must be removed through a separate vertical incision behind the tibial collateral ligament. The

technique of removal of the cartilage should be a purely instrumental one, including the sewing of the synovial layer and capsular ligament, which are separately sutured with catgut. Gauze dressings are applied, then large rolls of sterile cotton-wool extending from the ankle to the top of the thigh, and the limb is bandaged firmly enough to exert through the cotton-wool enough elastic pressure to control haemorrhage and effusion into the joint. The tourniquet is then removed: the object of placing it high up on the limb is to secure firm pressure of the bandage before it is taken off. No splints are required. Stitches should be removed in ten days.

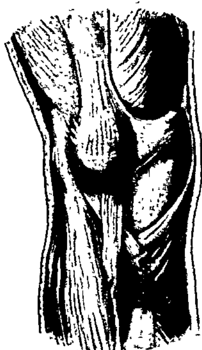


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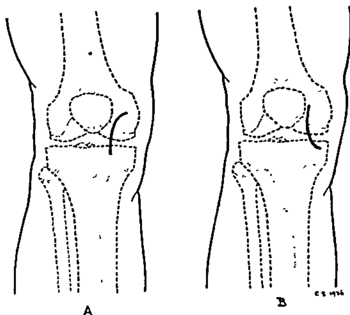


FIG 68. Incisions for Exposing the Medial Meniscus.
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skin closed. A plaster case is applied to immobilize the limb for some weeks, after which massage is employed.

Rupture of the Cruciate Ligaments.—After full exposure of the joint cavity, strips 15 cm. (6 in) in length are cut from the semitendinosus and gracilis tendons, the distal ends being isolated and brought down and the proximal ends sutured to the semimembranosus muscle. A strong pair of artery forceps is then thrust backwards through the inner part of the posterior ligament of the knee between the posterior horn of the meniscus and the head of the tibia. The two tendon strips are pulled forward with the forceps until their free ends project into the front of the joint. A hole is bored through the medial condyle of the femur in such a manner that it opens as far forward as possible on the medial aspect of the intercondylar notch. The tendons are piloted through this hole and pulled taut while the knee is fully extended. The free ends are turned downward, attached to the medial aspect of the medial tuberosity of the tibia, and the joint closed.

Arthroplasty of the Knee.—In ankylosis of the knee-joint resulting from injury, an attempt may be made to obtain a movable joint by the interposition between the bones of a flap derived from the fascia lata. The structures entering into the joint are freely exposed by Kocher's lateral J-incision. The ankylosed patella is freed from the femur, its lateral attachments are separated, and the patellar ligament and the upper end of the tibia are cleared. The portion of tibia to which the ligament is inserted is cut out with the Gigli or frame saw, preferably by the method of Payr (Fig. 71), as this permits of the integrity of the extensor apparatus being restored without having recourse to pegs or screws

The tibia and femur are separated from one another, and are pared so as to provide articular surfaces that will permit of free movement; in doing so, the lateral ligaments should be preserved as far as possible. A vertical incision is made through the skin and fat on the lateral aspect of the thigh, nearly as high as the greater trochanter, and a flap of fascia lata, fashioned on a pattern cut from a sheet of gauze, is raised from the muscle and brought through a tunnel made by undermining the skin and fat, it is then wrapped round the lower end of the femur, the shining surface facing the tibia, and is fixed by a series of catgut stitches. The bones are now apposed to one another the patellar ligament is reattached to the tibia, and the soft parts are brought together by separate tiers of suture.

If the ankylosis is due to fusion of the patella to the femur, a flap of fascia should be interposed between the bones after they have been separated

The *after-treatment* is prolonged. Traction is applied to the distal

Rupture of the Collateral Ligaments of the Knee.—*Edwards's Operation.*—A straight lateral incision is made exposing the fascia lata, the tendon of the biceps, the lateral condyle of the femur, and the head of the fibula A rectangular flap 7·5 cm. (3 in.) long is raised from the fascia lata with its base at the femoral condyle. This flap, also about 7·5 cm. (3 in) in length, is raised from the biceps tendon. The area on the lateral condyle where the ligament is normally attached is exposed and a small cavity 1·7 cm. (½ in.) in depth by 1·7 cm. (½ in.) in length is made in the vertical axis of the

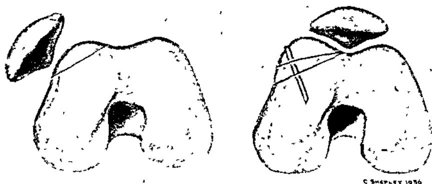


FIG 70. To illustrate Albee's Operation for Recurrent Dislocation of Patella

limb. A similar cavity is made on the head of the fibula The biceps flap is inserted into the groove on the lateral condyle and retained there with a small staple. The flap of fascia lata is turned down, inserted into the cavity on the head of the fibula, and maintained in position by a staple Both flaps are fixed in position while under strong tension, and a few stitches are placed to reinforce their attachments. The deep fascia is closed and the skin sutured

Medial Ligament.—A straight incision is made on the medial aspect of the knee, exposing the sartorius muscle from the lower end of its fleshy belly to the tendon close to its insertion By blunt dissection the tendons of the gracilis and semitendinosus muscles are exposed. Both these tendons are divided at the level of the medial condyle, dissected from their attachments, and pulled forward A groove is made on the medial condyle of the femur at the point of normal attachment of the ligament, and the tendons are fixed in the groove with a staple The proximal end of the gracilis and semitendinosus tendons are sutured to the sartorius so that active contractile function of these muscles is not lost The deep fascia is sutured and the

tendon and head of the tibia, and then from the lateral pouch and lateral surface of the femoral condyle. The supra-patellar pouch and medial reflection are cleared from above downwards. As much as possible of the posterior surface of the intercondylar space is stripped before closing the joint and superficial tissues with interrupted sutures. Haemostasis may be obtained by a tight compression bandage applied before the tourniquet is removed. The joint should be rested for fourteen days when graduated assisted exercises are begun to encourage the return of function. Weight-bearing is allowed when quadriceps control returns, usually in three to four weeks.

Arthrodesis.—(See p. 122.)

Operations in the Region of the Hip

According to the purpose in view, the joint is approached from the front, the side, or the back, by an incision which follows the line of cleavage of the overlying muscles and fascial planes.

Ankylosis of the Hip.—If ankylosis is in a bad position, this should be corrected by trans-trochanteric osteotomy, sub-trochanteric osteotomy, or the removal of a wedge.

The *trans-trochanteric operation* gives the most accurate mechanical result and should be practised in cases in which the femoral neck is preserved and there is no pathological displacement. Sub-trochanteric osteotomy is indicated when it is desirable to avoid the site of old disease. It is contra-indicated if there is extreme flexion. A *wedge osteotomy* is indicated when the head and neck of the femur are absorbed, in pathological dislocations, and in conditions in which there is much outgrowth of bone.

Access to the trochanteric region of the femur may be obtained by a vertical incision with its midpoint over the upper border of the trochanter, by a curved horizontal incision just below the greater trochanter, or by raising a U-shaped flap.

In the conditions for which osteoplastic operations are performed, the upper end of the femur is altered in shape, and the relationships of the bony points are correspondingly changed.

Osteotomy.—*Osteotomy of the Femur below the Trochanters.*—A suitable incision is made to expose the greater trochanter, and the bone is divided obliquely downwards, forwards, and medially, so as to prevent the lower fragment being displaced medially or abducted. The limb is put up in the abducted position.

Instead of a linear osteotomy, a wedge may be removed with its base directed laterally (Fig. 72)

Trans-trochanteric Osteotomy—This is performed most frequently for the adduction-deformity resulting from hip disease or coxa vara. The osteotomy may be linear (Fig. 73) or cuneiform (Fig. 74). If a

fragment to keep the surfaces apart, and is maintained for about a month. Meanwhile the joint is immobilized in a plaster case in the semiflexed position for ten days, after which movements are commenced, without relaxing the traction. The movements should be made by the patient using his muscles voluntarily, and not passively by the surgeon. The use of hot-air baths, electrical stimulation, and massage is continued for some months The joint is apt to become

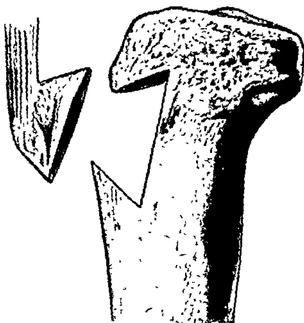


Fig. 71 Method of detaching the Insertion of the Ligamentum Patellae. (Payr)

stiff towards the end of the first month, but the stiffness usually passes off.

Campbell's operation is preferred by some. The lower end of the femur is rounded off to form a single U-shaped condyle which is adjusted to fit a shallow trough in the upper surface of the tibia; a space of about 1·7 cm. (½ in) is left into which the infra-patellar pad of fat supplemented by a free transplant of fascia lata is fixed. Moderate traction (7–8 lb) is applied and the limb is fixed in a Thomas's knee splint.

Synovectomy.—In cases of atrophic or rheumatoid arthritis removal of the grossly inflamed and thickened synovial membrane may add greatly to the comfort of the patient and to the function of the joint. The joint is freely exposed and the capsule is stripped off the bulging and thickened synovial membrane as the patella is displaced laterally The synovial membrane is freed from the patellar

similar lines, but the upper end of the lower fragment is not brought against the centre of the acetabular socket, but is transferred to a lower point to rest below the inferior margin of the acetabulum (Fig. 75). The exact position to be maintained by the upper end of the lower fragment must be made clear by careful exploration with the operator's index finger; correct placing is necessary, and should be controlled by X-ray examination. In applying the plaster spica, it is important that the hip should be flexed to about 15 degrees, lest the upper end of the lower fragment may press forward on the femoral vessels. It is a good plan to make raw the lateral side of the cortex of the lower fragment, so that where

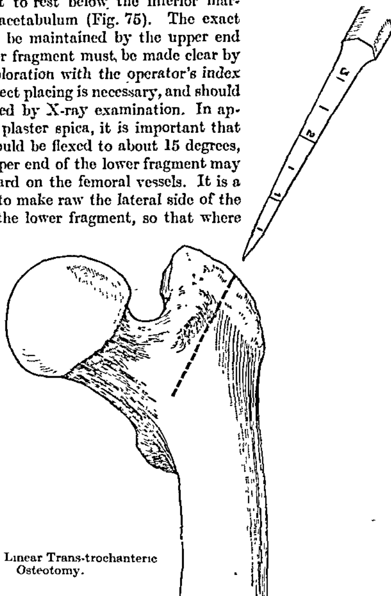


Fig. 73 Linear Trans-trochanteric Osteotomy.

the upper fragment comes into contact with it raw cancellous bone will meet raw cancellous bone to promote firm union.

Mobilization operations for ankylosis of the hip are usually confined to cases with bilateral ankylosis. If the usual adduction deformities are present, one hip should be submitted to osteotomy and the other to pseudarthrosis

Arthroplasty.—The reconstruction of an ankylosed hip to restore

linear osteotomy is sufficient to correct the deformity, the bone is divided obliquely from above downwards, forwards, and medially from near the tip of the greater trochanter to the lesser trochanter. If a cuneiform resection is necessary, a wedge is removed with a large osteotome or chisel, irrespective of the muscular attachments, the base of the wedge being at the junction of the greater trochanter with the neck, and the apex in the region of the lesser trochanter (Fig 74). The size and shape of the wedge depend on the nature of the deformity, which should be ascertained by stereoscopic radiograms.

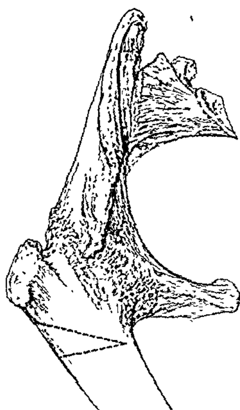


Fig 72 Cuneiform Osteotomy below the Trochanters.

Lorenz Bifurcation Operation —This operation may be carried out for irreducible dislocation of the hip, or in cases of ununited fracture of the neck of the femur when the patient is not able to walk without pain.

A sand-bag is placed under the affected buttock and an incision made from the greater trochanter downwards for about 15–20 cm. (6–8 in.) The femur is exposed and freed from the surrounding muscles A long oblique osteotomy is carried out, passing upwards and medially towards the lesser trochanter (Fig 76) The leg is brought into abduction so that the upper part of the lower fragment comes to lie against the centre of the acetabular socket. The upper part of the femur remains in place, but the cut surfaces of the upper and lower fragments are in contact and unite so that eventually the result is a Y-shaped upper end to the femur, hence the name 'bifurcation operation'. A complete plaster spica is then applied from the waist to the toes, with the limb suitably abducted and with about 15 degrees flexion at the joint This remains in place for twelve weeks. Weight is not borne until the end of that period, when a walking caliper may be fitted.

For the relief of osteoarthritis, the operation is carried out on

Replacement of Paralytic Dislocation by Open Operation.—The joint is exposed by an anterior longitudinal incision, the contracted muscles—tensor fasciae latae, rectus, vastus lateralis, and possibly also a part of the ilio-psoas—are divided and the joint is opened. The shortened ilio-femoral ligament is divided, the glutei,

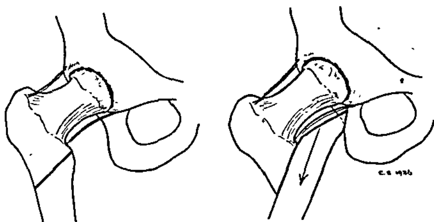


FIG. 75. Lorenz Bifurcation Operation for Osteoarthritis of Hip-joint.

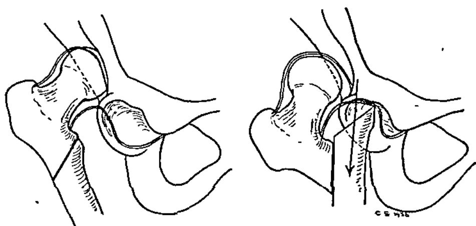


FIG 76 Lorenz Bifurcation Operation for Congenital Dislocation of Hip-joint.

obturators, and piriformis are dissected off the greater trochanter, and the head of the bone is replaced by a powerful movement of adduction If the acetabulum is too small, it is enlarged with a gouge.

Arthrodesis of the Hip-joint.—(See p. 128.)

Congenital Dislocation of the Hip.—In children over the age of three, in whom manipulation has failed to reduce the dislocation, operation is usually indicated. It is not advisable to make any

some degree of movement is effected by a plastic operation in which the joint is freely exposed from the front, and the constituents of the joint moulded as far as possible to their original shape. The head of the femur is reshaped with reamers and covered with a vitallium cap (Smith-Petersen), and the acetabulum is hollowed out to receive it.

Pseudarthrosis without Disarticulation of the Head.—This consists in making a false joint in the position of the neck of the

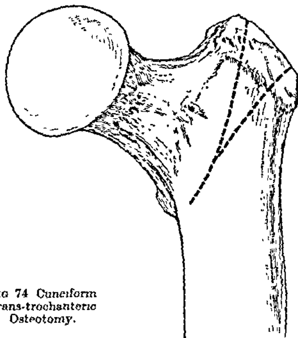


Fig 74 Cuneiform Trans-trochanteric Osteotomy.

femur (Fig 77). This operation is reserved for weakly patients who would not stand the shock of opening the joint. It is also useful in cases in which a mass of bone has formed round the joint, and in cases of tuberculosis which have resulted in ankylosis in a bad position, in which the head and neck of the bone have been preserved. A longitudinal incision is made with its midpoint at the upper point of the greater trochanter, and a second incision divides the periosteum across the base of the trochanter just below the insertion of the gluteal muscles. A slice of the trochanter from this point to its junction with the neck above is sawn or separated with a wide osteotome and retracted upwards. The capsule is opened and the neck separated from the head with an osteotome Extension is now applied to the femur and the trochanter with its muscles attached is fixed to the head of the bone which remains in the acetabulum.

Replacement of Paralytic Dislocation by Open Operation.—The joint is exposed by an anterior longitudinal incision, the contracted muscles—tensor fasciae latae, rectus, vastus lateralis, and possibly also a part of the ilio-psoas—are divided and the joint is opened. The shortened ilio-femoral ligament is divided, the glutei,

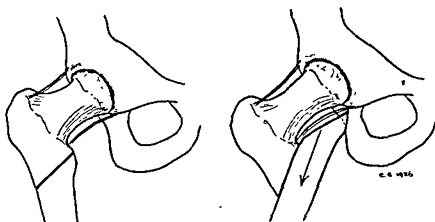


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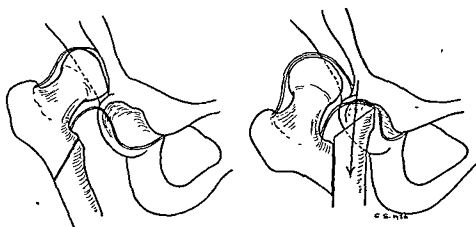


FIG. 76 Lorenz Bifurcation Operation for Congenital Dislocation of Hip-joint.

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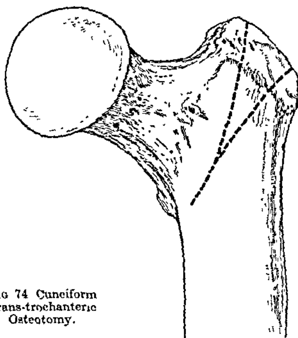


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gluteal, adductor, and extensor groups, are practised after the grafts are seen in radiographs to have become consolidated. Weight-bearing may begin in about three months.

Flexion Contracture of the Hip.—In certain cases of poliomyelitis affecting the gluteal muscles, in which the tensor fasciae latae muscle remains active, a severe flexion contracture of the hip may develop. Several degrees of flexion can be corrected without operation in the following manner. Both hips being flexed, the trunk and the lower extremity of the healthy side are immobilized in a plaster case. Extension straps are then applied to the lower extremity of the affected side, and a Thomas's knee splint slipped on the limb. The limb is extended in the knee splint by traction, and the lower end of the splint is tied to the lower end of the bed, which is raised on high blocks. By gradually lowering the height of the blocks and by lowering the level of the distal end of the splint towards the mattress, the contracted structures are stretched.

Operation is sometimes required, however, and the best results are obtained by the operation of transference of the crest of the ilium (Campbell). The structures most actively holding the thigh in flexion, named in the order of benefit secured by the release of each, are the rectus femoris, sartorius and tensor fasciae latae, gluteus medius and ilio-psoas muscles, and the ilio-femoral ligament. The incision begins at a point 1·7 cm. (½ in.) below the midpoint of the crest of the ilium, and extends forward to the anterior spine, and thence downwards on the thigh along the medial border of the tensor fasciae latae muscle for about 15 cm. (6 in.). The superficial and deep fasciae are incised down to the crest of the ilium, and the anterior superior spine with its muscular attachments is chiselled off. The outer fourth of the iliac crest is chiselled off from before backwards. With a heavy periosteal elevator all the muscles on the lateral surface of the ilium are stripped down subperiosteally to the upper rim of the acetabulum. With a sharp osteotome an area on the outer surface of the ilium about 8 cm. (3 in.) long, just above and parallel to the acetabulum, is denuded and roughened. This is to receive the gluteal muscles and bone removed from the iliac crest, and to form its new attachment. This procedure is practically bloodless if done subperiosteally.

The attachment of the iliacus to the medial surface of the ilium is next stripped in a similar manner, leaving the denuded ilium exposed in the wound. The tissue between the anterior superior and anterior inferior spines is now loose, exposing the attachment of the rectus femoris. The heavy broad tendon of this muscle still forms the main obstacle to the correction of the flexion deformity, and it may be released either by stripping it from its attachments to the anterior

attempt at manipulative reduction on the operating table immediately before operation.

Reduction by Open Operation.—The joint is exposed by an anterior incision (Smith-Petersen). The capsule of the joint is usually found adherent to the pelvis, particularly above the acetabulum, and must be freed; it is then incised in the line of the head and neck of the femur. Adhesions obstructing reduction are freed, and the ligamentum teres, which is often abnormally large, is removed. The socket

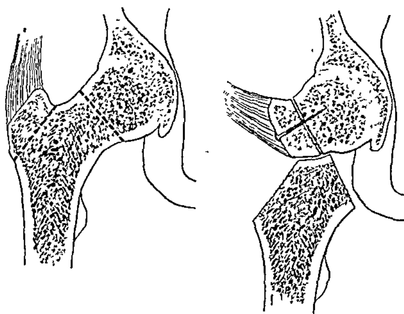


FIG 77 Jones's Operation of Pseudarthrosis for Ankylosis at the Hip

is cleared and reduction effected. The capsular ligament is reefed in an overlapping manner. The muscles and fascia lata are brought together, and the skin sutured. The limb is then put up in a plaster spica in a position of 40 degrees' abduction, with the head of the femur sufficiently rotated to ensure that it is well thrust into the acetabulum

The details of this standard operation have to be modified to meet the conditions of individual cases. For example, it may be necessary to deepen the socket by reconstructing the upper margin of the acetabulum. The gluteal muscles with a flap of periosteum above the posterior margin of the acetabulum are raised, and the margin of the bone is prised downwards with an osteotome till it overlaps the head of the femur, the space being filled with a bone graft supported by bone pegs acting as struts

In the after-treatment exercises for the muscles, particularly the

palmar crease exposing the tendon; the sheath is incised laterally in its long axis and allowed to open. When the skin wound has healed active movement is allowed.

A painful form of stenosing tenosynovitis may affect the extensor or abductor tendons of the thumb. The contracted segment of the

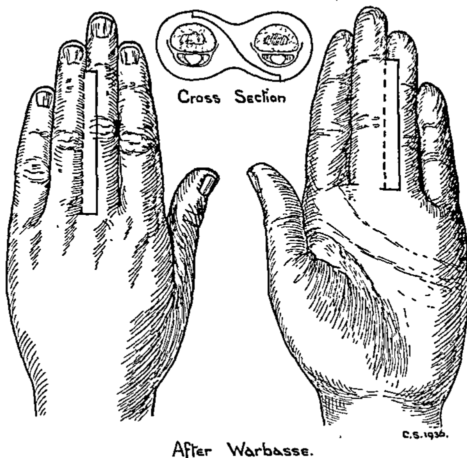


FIG 78. Operation for Syndactylism

sheath is opened longitudinally through an incision over the painful area

Syndactylism. Webbed Fingers.—In cases in which the phalanges are present and there is a web connecting the fingers, an incision the length of the web is made on the dorsum of one finger and across the web at its top and bottom, and a quadrilateral flap dissected back. Another incision is made the length of the other finger on its palmar surface, and transverse incisions from each end of this, and a palmar flap dissected up. The dissection of these two flaps splits the web and makes a flap for covering the raw surface on each finger. The flaps are sewn in place by fine suture (Fig. 78).

inferior spine, or by the simpler and more effective method of extending the dissection and exposing about 5 cm. (2 in.) of the tendon, passing a director under it, and completely dividing it. The dissection is lateral to the femoral vessels and nerve.

In most cases full extension of the hip in the abducted position can now be obtained, but occasionally it is necessary to divide the contracted fibrous tissue forming the anterior capsule of the hip-joint, of which the ilio-femoral ligament is the most resistant structure.

It is rarely necessary to divide the psoas muscle as it usually stretches without difficulty. If possible, its function should be preserved.

Before beginning the closure about 1·7–2 cm. (½–¾ in.) of the anterior portion of the projecting iliac crest is removed and the bone smoothed off to obviate the troublesome protrusion caused by dropping the attachments of the gluteal and flexor muscles.

The anterior superior spine is placed against the ilium at about the normal level of the anterior inferior spine, and the fascia closed over it. When the crest of the ilium is reached, the deep fascia of the medial side is sutured to the subcutaneous tissue of the lateral side. This serves the double purpose of rolling the gluteal muscles and the bone removed from the iliac crest downwards to their new attachment above the acetabulum, and of placing the skin incision about 2·5 cm. (1 in.) below the iliac crest to avoid pressure.

A plaster spica is applied extending from the axilla to the toes on the affected side for eight weeks.

Loeffler's Operation for Lateral Rotation of the Hip in Poliomyelitis.—A 12-cm (5-in.) vertical incision is made with its midpoint over the greater trochanter. The deep fascia is split from above downwards about 3 cm (1¼ in.) anterior to the trochanter. The limb is then rotated medially and the posterior margin of the fascia drawn behind the trochanter and sewed in a groove cut in its posterior surface

Cheilotomy.—This operation is employed in certain cases of osteo-arthritis to remove the outgrowths or lipping round the articular margin of the head of the femur and acetabulum. Kocher's postero-lateral incision is used; the osteophytic outgrowths are removed piecemeal until the desired range of movement is secured

Operations on the Upper Extremity

Trigger Finger.—The sudden snapping of the finger is due to inflammatory thickening of the flexor tendon sheath at the level of the metacarpo-phalangeal joint, where the sheath is normally narrowed by the accessory volar ligament (palmar ligament of metacarpo-phalangeal joint). An incision is made in the line of the

For ordinary occupations a solid fusion of the wrist is compatible with good function.

Club-hand Deformity.—In the congenital form of club-hand the deformity may be corrected by transposition of the distal end of the ulna into the carpus. The fusion may be effected by wedging the lower end of the ulna directly into a slot made in the carpus; by splitting the lower end of the ulna and wedging the carpus into the fork; or by dividing the ulna obliquely from the medial to the lateral side, and after manipulating the hand into the straight position, pushing the sharp edge of the ulna into the carpus and using a peg to fix the bones in their new position. The operation improves the appearance of the limb, but does little to add to its usefulness.

Club-hand deformity resulting from interference with the growth of the lower radial epiphysis, with consequent disproportionate growth of the ulna, is treated on the same lines as traumatic club-foot (p. 160).

Osteotomy of one or both bones of the forearm, which may be linear or wedge-shaped according to the nature of the deformity, is performed for malunited fracture of the lower end of the radius or ulna; for Madelung's deformity of the wrist; or for valgus or varus deformity of the elbow.

In lesions of the inferior radio-ulnar joint,causing loss of rotatory movement, a false joint may be formed higher up than the normal one by removing a segment of bone about 2·5 cm. (1 in.) long from the shaft of the ulna, under cover of the pronator quadratus. Movement is commenced as soon as the wound has healed.

Pronator Spasm.—In some cases of spastic paralysis the persistent contraction of the pronator quadratus can be relieved by operation. The muscle is exposed through an incision 5–7 cm. (2–3 in.) long, the flexor tendons and the radial artery are retracted, and the quadratus muscle dissected off the bones The forearm is held in the supine position, with the elbow flexed, in a plaster cast which extends to the axilla After three weeks active re-educative movements are commenced.

If full supination is limited by fibrotic shortening of the pronator teres, the insertion of this tendon into the radius is freely divided.

Tennis Elbow.—If treatment by manipulation fails to give relief, an oblique incision is made from above the lateral condyle downwards and forwards in the line of the radius, the extensor fibres are separated from their attachment to the epicondyle to relieve the pull on the bone. If a bursa is present it should be removed.

Arthrodesis of Elbow.—(See p. 115.)

Arthroplasty of Elbow.—(See p 115.)

Operation for Recurrent Dislocation of the Shoulder.—

Dupuytren's Contraction of the Palmar Fascia.—In cases of moderate severity, subcutaneous division of the contracted fascia in the palm and of its prolongations on to the fingers, and free separation of the fascia from the overlying skin with the tenotomy knife are sometimes sufficient.

In more advanced cases the contracted fascia may be excised by open dissection through an incision along the ulnar border of the palm curving round the hypothenar eminence within the projection of the pisiform bone A sufficient amount of fascia is removed to permit of hyperextension of the affected fingers.

In severe cases in which the fingers are markedly flexed and the skin is wrinkled and dimpled by being incorporated with the contracted fascia, it is best to excise the affected area of skin and fascia, and to cover the resulting raw area with a graft.

After any of these operations, prolonged splinting, massage, and exercises are necessary to prevent recontraction.

Volkmann's Ischaemic Contracture.—For the fully established condition many operations have been attempted, such as excision of the carpus, shortening the radius and ulna, multiple lengthening of the flexor tendons, and sliding down the origin of the flexor group from the medial condyle and upper end of the radius and ulna. These operations are complicated in performance and uncertain in result

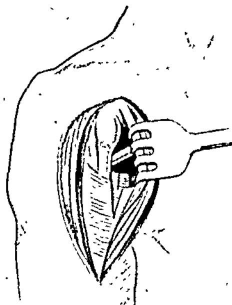
Arthrodesis of Wrist.—(See p. 111.)

Metacarpo-carpal Arthrodesis.—In certain cases of paralysis affecting the abductor and opponens muscles of the thumb, the inability to oppose the thumb to the fingers is so great that fusion of the thumb in a position of abduction and opposition is justified by the improvement in function which it gives.

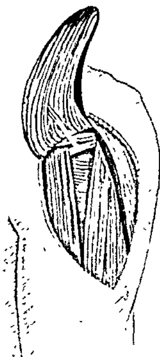
A short incision is made over the joint on the antero-lateral surface; the abductor pollicis brevis and the opponens are retracted; the thumb is swung into the position of grasp, and the opposing surfaces of the trapezium and metacarpal are then excised with a fine osteotome. A bone graft can be inserted between the joint surfaces The position is maintained by a plaster slab for at least six weeks.

Arthroplasty of Wrist.—In cases of bony ankylosis, the joint may be mobilized and bone resected through a longitudinal incision on the radial side of the dorsum between the long extensors of the thumb and index. By continuing the incision upwards and undermining the skin, a flap of fascia and fat is obtained which can be made to cover the articular end of the radius In many respects a free flap from the fascia lata of the thigh is to be preferred.

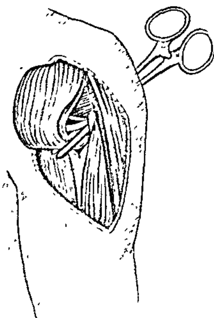
This operation is called for only when a certain amount of movement is essential for an occupation which involves fine movements.



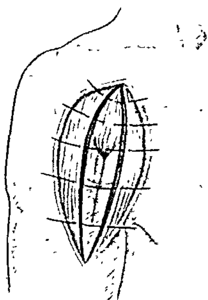
A



B



C



D

Fig 79. Steps in Operation for Recurrent Dislocation of Shoulder. (Clairmont.)

A Quadrilateral space

According to the cause of the instability of the joint, different methods of strengthening it are employed: augmenting the suspension apparatus, reinforcing the capsule and glenoid rim, or forming an osseous block.

Clairmont's operation illustrates the suspension method. An incision 12 cm. (5 in.) long is made, extending from the coracoid process downwards to the lateral side of the anterior border of the deltoid. The fibres of the deltoid are separated, and after dissection the quadrilateral space is clearly defined (Fig. 79 A). This space is now slightly enlarged by dividing the upper third of the tendon of the teres major muscle. A second incision is then made parallel to the lateral side of the posterior border of the deltoid, and through it a flap including at least a fourth of the deltoid and its tendon is detached from the humerus. With ordinary care the nerve supply to this flap is not injured. The flap is then passed from behind forward, through the enlarged quadrilateral space (Fig. 79 C), and sutured to the split anterior portion of the deltoid (Fig. 79 D).

In *Nicola's operation* the shoulder-joint is exposed by the anterior route. A fine black silk suture is placed through the biceps tendon *near its distal end, and the tendon is divided proximal to this suture* either obliquely or by a Z-shaped cut. A second suture is placed through the distal cut end of the proximal piece of the tendon and the ends of the suture left long With a quarter-inch drill, a tunnel in the humerus about 5 cm (2 in.) long is made underneath the biceps tendon. This tunnel is directed obliquely and so placed that the proximal aperture is at the junction of the cartilaginous edge of the head of the humerus and the proximal end of the bicipital groove. This allows the long tendon of the biceps to be passed through the tunnel without any sharp angle (Fig. 80).

Bankart's operation is designed to deepen the glenoid socket and reinforce the capsule. Through an anterior incision the coracoid process is exposed and its tip, with the attached muscles, divided with an osteotome and turned downwards The subscapularis is exposed, and after a suture has been passed through its fibres 2·5 cm. *(1 in) from its attachment, it is separated* with the capsule and turned down If the glenoid is deficient a flake of bone is raised with an osteotome, and with a stainless steel staple, or by tightening the sutures in the subscapularis, the capsule is held firmly against the roughened area on the glenoid margin The coracoid process is then replaced and sutured in position

The *bone block method* is applied in various ways, for example, by inserting a tibial graft 4 cm ($1\frac{3}{4}$ in) into the antero-inferior aspect of the neck of the scapula, passing obliquely backwards and inwards across the anterior surface of the joint (Speed).

centre. This area is incised, and the putty-like material exposed and removed with a sharp spoon.

Paralysis of the Serratus Anterior Muscle.—*Wing-scapula.* —To relieve the disability resulting from paralysis of the serratus, the sternal portion of the pectoralis major may be detached from the humerus and from the front of the chest sufficiently to admit of the separated portion being carried round the ribs beneath the scapula,

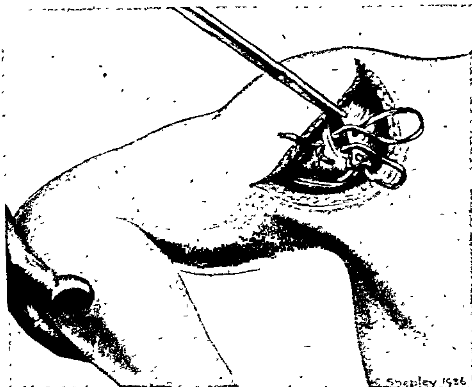


FIG. 81. Operation for Rupture of Supraspinatus Tendon. (P. D. Wilson.)

and sutured to the serratus as far towards the vertebral border of the scapula as possible The operation is carried out through a curved incision across the axilla from the vertebral border of the scapula to the bicipital groove of the humerus.

Congenital Elevation of the Scapula.—An incision is made along the upper and vertebral borders of the scapula and all tissues that restrain the replacement of the scapula are divided, bony attachments, if present, being removed. The deformity is then forcibly corrected. A hole may be bored in the lower border of the scapula through which a band of muscle and fascia from the latissimus dorsi is passed and reattached to the muscle under tension. A plaster casing is applied to maintain the correction. Care must be taken to

Without disturbing the coracoid process, Noordenbos displaces the biceps and coraco-brachialis laterally, and inserts a peg-shaped bone graft taken from the fibula into the neck of the scapula. The limb is retained in the abducted position in a plaster spica for six weeks.

Arthroplasty of the Shoulder-joint.—The joint is freely exposed by the usual anterior incision, and the head of the humerus is thoroughly mobilized by dissecting away scar tissue and removing new bone. The head of the humerus is then completely covered by a flap of fascia, taken either from the vicinity or from the fascia lata of the thigh.

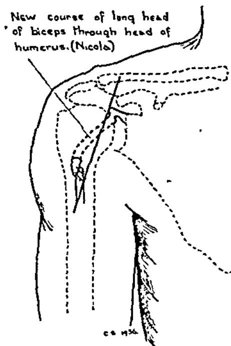


Fig. 80 To illustrate Operation for Recurrent Dislocation of Shoulder by Nicola's Method

Arthrodesis of the Shoulder.—(See p. 116.)

Rupture of the Supraspinatus Tendon.—A wide exposure of the tendon is necessary by Codman's 'sabre cut' incision, crossing over the lateral end of the shoulder girdle. This incision follows the origin of the deltoid, which is detached and turned downwards; the base of the acromion may be cut through in the flap. The fibrous end of the tendon is excised. With a sharp osteotome a channel is cut transversely in the anatomical neck of the humerus and the medial edge of the greater tuberosity, to provide a new bed for the tendon Using a $\frac{3}{16}$-in. drill, holes are now drilled through the lateral surface of the humerus below the greater tuberosity into this channel From four to seven holes are required about 0 5 cm ($\frac{1}{4}$ in) apart Sutures of stout silk are passed through the edges of the tendon and through the drill-holes in turn, again through the tendon, and back through the next drill-hole (Fig. 81).

After the operation the shoulder is fixed on a light wire platform splint in a position of 90 degrees abduction, which is maintained for at least three weeks

Calcification in Tendon of Supraspinatus Muscle.—The deposit is approached through an incision starting from the acromion process and splitting the deltoid fibres downwards. Deep retractors are inserted. A soft, inflamed area is discovered with a yellowish

centre. This area is incised, and the putty-like material exposed and removed with a sharp spoon.

Paralysis of the Serratus Anterior Muscle.—*Wing-scapula.* —To relieve the disability resulting from paralysis of the serratus, the sternal portion of the pectoralis major may be detached from the humerus and from the front of the chest sufficiently to admit of the separated portion being carried round the ribs beneath the scapula,

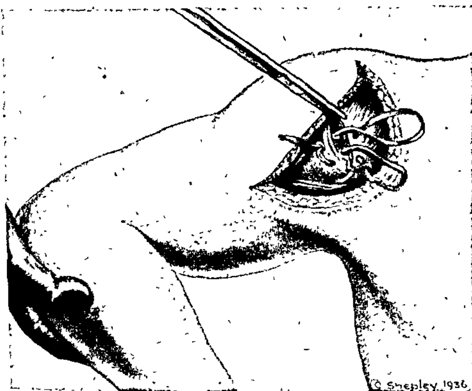


FIG 81. Operation for Rupture of Supraspinatus Tendon. (P. D Wilson.)

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avoid injuring the brachial plexus, or exerting pressure on it by the clavicle.

Complete Acromio-clavicular Separation.—In this condition the articular surfaces of the joint must be approximated and the conoid and trapezoid ligaments reconstructed (Bunnell) An incision through the skin and subcutaneous tissue is made over the tip of the shoulder. The torn capsule of the joint is exposed and, by blunt dissection, the coracoid process is freed so that suture material may be passed underneath it. A hole is drilled in both the acromion and clavicle. A long fascial suture is then passed through the drill-holes, forming a figure of eight which includes the coracoid process. The joint capsule is closed with interrupted sutures.

A modification of this operation is to suspend the coracoid beneath the clavicle by means of sutures passed through both these bones.

Chronic Subacromial Bursitis.—The operation consists in removal of the bursa and any deposits that may have formed within it, or in the tendon of the supraspinatus muscle. The bursa is exposed by an incision beginning at the tip of the acromion and extending about 7·5 cm. (3 in) parallel to the bicipital groove. The fibres of the deltoid are separated down to the bursa The bursal sac is opened, its limits defined by rotating the humerus, and the sac removed. The wound is closed without drainage

W. V. A.

CHAPTER IX

PLASTIC SURGERY

Principles. Methods: Free Grafts; Flaps. Individual Plastic Operations: On Eyelids; On Eye-socket; On Buccal Sulcus; On Nose; On Face.

The procedures employed in plastic surgery vary from the simple transplantation of portions of skin in order to hasten the healing of open surfaces, to elaborate dissections for the restoration of tissue, or for the correction of deformities. As each individual case presents problems of its own, the choice between the methods available calls for careful consideration. The tissue to be transferred must be selected in the light of the texture of that to be replaced, and with due consideration to the secondary effects on the region from which the tissue is borrowed.

Plastic operations demand very delicate handling of the parts, the most complete asepsis and haemostasis attainable, accurate adjustment of grafts and flaps without tension and with a secure blood-supply, and precautions to avoid displacement of dressings by appropriate means of immobilization.

Methods.—The tissue used for transplanting may be in the form of free grafts or of flaps. Free grafts being completely separated from the body acquire their nourishment from the recipient bed; flaps are nourished from the general circulation through their pedicles.

If it is necessary to remove granulations from the area to be grafted, bleeding is arrested by pressure with a pad of gauze wrung out of hot saline solution. Thrombin solution can be applied to the granulations or to the deep surface of the graft to arrest oozing and to favour fixation.

Free Grafts—Free grafts may consist of portions of skin, of mucous membrane, adipose tissue, fascia, cartilage, bone, or of cornea according to the purpose for which they are intended.

Owing to its tendency to wrinkle and contract, the Thiersch epidermal, or *thin razor graft*, is now seldom employed. The *thick razor graft*, which consists of epidermis and about 80 per cent. of the dermis, is the form most generally useful. These grafts are cut with a special knife (Blair) or if this is not available, by a hollow-ground razor, and they are applied in sheets or strips, or in portions about the size of a postage stamp, to fresh traumatic wounds, or to granulating surfaces resulting from burns or ulceration.

The graft is usually taken from the medial or lateral aspect of the thigh or from the medial aspect of the upper arm. A small wooden board is used to keep the skin taut. The under surface of the blade

avoid injuring the brachial plexus, or exerting pressure on it by the clavicle.

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A modification of this operation is to suspend the coracoid beneath the clavicle by means of sutures passed through both these bones

Chronic Subacromial Bursitis.—The operation consists in removal of the bursa and any deposits that may have formed within it, or in the tendon of the supraspinatus muscle. The bursa is exposed by an incision beginning at the tip of the acromion and extending about 7·5 cm (3 in) parallel to the bicipital groove. The fibres of the deltoid are separated down to the bursa. The bursal sac is opened, its limits defined by rotating the humerus, and the sac removed. The wound is closed without drainage.

W. V. A.

of the defect to be covered, and when enough have been cut, are transferred to the recipient area about 1 cm. (½ in.) apart, covered with tulle-gras, saline swabs, and a wool pressure dressing, and the part is immobilized.

Grafts of mucous membrane are used to cover defects of the lip or conjunctiva.

Grafts of adipose tissue, taken from the abdominal wall, are sometimes used to restore the contour of exposed parts of the face and neck. Allowance is made for the bulk of the implanted tissue shrinking by about 50 per cent.

Cartilage grafts.—Portions of cartilage with the perichondrium intact are used in the repair of defects of the nose and to build up facial defects. The graft is shaped as required and can be hinged in position by means of the perichondrium, or it may be cut into small squares (diced) or grated before implantation, to facilitate the moulding process.

Bone grafts are used in various plastic operations, such as the reconstruction of the bridge of the nose, the repair of mandibular defects, or the restoration of facial contour. The graft is conveniently taken from the crest of the iliac bone, and may be inserted entire, or broken up into chips and packed into position.

Acrylic prostheses.—The acrylic plastics formed from the oxidation of acroline (a product of the distillation of glycerin) are employed frequently in maxillo-facial surgery as prostheses. They are cast to cover bone defects and are inserted under the skin and muscle. A few brilliant results have been achieved on the one hand, while on the other, complications such as local tissue reaction, collections of serum, and the entrance of infection have occurred.

Flaps.—Many methods have been devised to obtain tissue for the repair of defects by means of flaps. These are so numerous that their nomenclature has become somewhat involved. It is sufficient here to indicate the general nature of the technique employed without entering into operative details Flaps can be raised 'local' to the defect, 'direct' from some other part of the body adjoining the defect, or carried from a 'distance' via an intermediary host.

Examples of local flaps are the straight advancement, the transposition, and the rotation.

Undercutting surrounding skin is perhaps the simplest and most obvious method of finding a covering for small defects. The gap is delimited by an incision round its edge, the adjacent skin is undercut sufficiently to admit of it being mobilized to cover the raw surface, and sutured in position. The *straight advancement flap* is formed by the free mobilization of a rectangle of skin adjoining the defect, followed by its advancement (Fig. 83). It is employed with

and the narrow edge of the board are smeared with vaseline, and with the board moving about 2·5 cm. (1 in.) in front of the blade in a distal direction, the graft is cut with a sawing movement. The graft which collects on the blade is laid, skin surface down, on tulle-gras previously spread on a board and transferred thence to the raw surface.

Similar grafts may be cut with the dermatome (Padgett), a mechanical device to cut grafts of any thickness from any surface of the body. The cutting blade acts in association with a revolving drum actuated by a hand grip The donor skin and the drum are smeared with an adhesive cement, and when this is nearly set, the blade is adjusted to the required level, and the graft as it is cut passes on to the drum, from which it is transferred to tulle-gras before being placed on the raw surface. The graft is trimmed to fit the defect, and when two or more grafts are used they are made to overlap. Various forms of 'plasma glue' can be employed to cause the graft to adhere. Silk stitches are inserted round the edges to fix the graft, the ends being left long to tie over wool impregnated with proflavine-paraffin emulsion More wool is then applied, and fixed with a crêpe bandage. In seven days the first dressing is carried out.

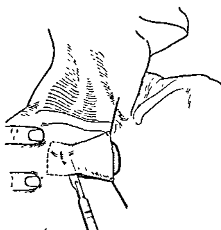


Fig. 82. To illustrate method of Cutting Whole-thickness Graft.

Whole-thickness (*Wolfe*) *grafts* (Fig 82), which are more flexible and of better texture than razor grafts, are indicated in small areas of skin loss in face, in ectropion of the lower eyelid, and in defects of the palmar aspect of the hand. An exact pattern of the defect is traced on the part from which the graft is to be taken; an incision is made through the skin, not including the subcutaneous fat; the graft is raised by dissection and transferred directly to the defect It is fixed in position with the finest silk sutures.

To restore the eyebrow, a whole-thickness *hair-bearing graft* is taken from the temporal or the mastoid region.

The *deep pinch*, or Staige Davis graft, which consists of a small circle of skin, about 0 5 cm. (¼ in) in diameter, is made by pinching up a small cone of skin with a sharp needle, and cutting through the base with a scalpel, under local anaesthesia. The grafts as they are cut are placed on a moist gauze swab of the exact size

stage it is raised and attached to the recipient area. Three weeks later the pedicle is severed.

The Tubed Pedicle Graft.—By this method skin and fat can be transferred via an intermediate host, e.g. the wrist, from suitable sites of the body to areas requiring to be covered.

The anastomotic pedicle is usually fashioned on the neck or the abdomen.

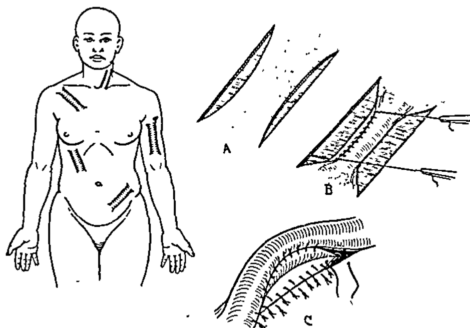


FIG. 85. To illustrate suitable Donor Sites, and formation of Tubed Pedicle Graft.

A Incisions through skin: stippled area = extent of undercutting
B Undercut skin formed into a tube by sutures.
C Tube isolated skin sutures beneath it

First Stage.—By means of two parallel incisions and by undercutting between them, a strip of skin of the required length is raised and formed into a tube by suture of its free edges (Fig. 85). The pedicle should have a ratio of breadth to length of approximately 1 to 3. In the neck the platysma, and in the abdomen a thin stratum of fat, is raised with the skin to form a core for the tube. On the abdomen it is advisable to curve and stagger the parallel incisions slightly so that when the pedicle is raised above the level of the underlying skin it will occupy the shortest distance between the two points of attachment without the tension which is present if straight incisions are employed. Both ends are left attached. The skin edges adjacent to the tube are widely undercut and drawn together below the tube.

advantage in the neck. A second type of advancement flap is the V–Y method (Fig. 83).

Direct Flaps.—The method aims at closing a defect with skin borrowed from another part of the body when a covering cannot be found from a local source; for example, in an extensive ulcer of the hand or forearm following a burn the tissue may be borrowed from

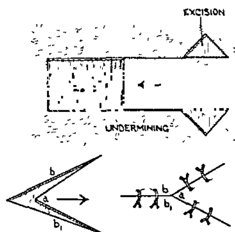


Fig 83. Diagram to illustrate Undercutting and Suture b, a, b illustrates V–Y method.

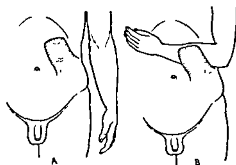


Fig. 84 Diagram to illustrate use of Direct Flap to cover defect on back of Forearm.

A. Flap raised
B Flap in position covering defect

the abdominal or the thoracic wall (Fig. 84). Flaps to cover defects of the leg are obtained from the other leg (cross leg)

To plan the operative procedures, the necessary steps are considered in reverse. First, the defect is covered with jaconet cut to its shape. Next the recipient is approximated to the donor area and the jaconet allowed to fall across the latter site. The flap can then be mapped out on the chest, abdominal wall, or calf. At the first

Second Stage.—For a period of three weeks the end which is to be first divided is daily constricted by tape or thin rubber tubing to develop the anastomotic channels at the other end. When the blood-supply appears to be satisfactory, the pedicle is mobilized by freeing one end, which is then implanted on the intermediate host or to the edge of the defect.

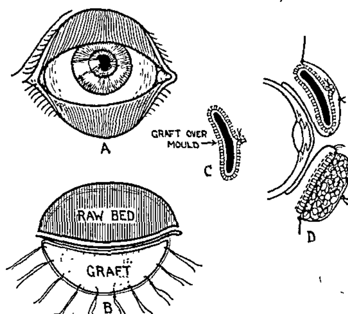


FIG 86 To illustrate Correction of Ectropion

A Appearance before treatment showing ectropion of both lids
B Whole-thickness graft applied to lower lid.
C Razor-graft on Stent mould ready for insertion to upper lid
D, Vertical section showing grafts in position

Third Stage—After the lapse of a fortnight the remaining attachment is set free and the pedicle opened throughout its full length to fill the defect completely

Individual Plastic Operations. *Eyelids.*—To correct cicatricial eversion of the upper eyelid—*ectropion*—the scar tissue is excised, under local anaesthesia, by incising from canthus to canthus outside the ciliary margin and freeing the orbicularis fibres as far as possible from the scar tissue without injury to the levator muscle. An exact mould of the raw surface is taken in dental stent and a free razor graft, taken from the inner aspect of the upper arm, is wrapped round it [illegible] The graft-covered stent is [illegible] with fine sutures In one [illegible] is removed.

In the *lower lid* a whole-thickness graft is used. A probe is inserted into the lacrimal duct, the scar tissue is excised, and the graft, cut to

when cutting off the nose was the recognized punishment for certain offences in India. The defect was made good by a pedicled flap turned down from the forehead. In the sixteenth century Tagliacozzi

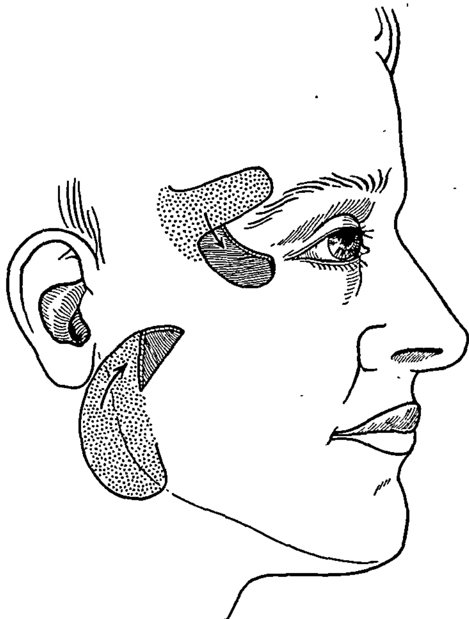


FIG 89 To illustrate use of local Pedicled Flaps in closure of Cutaneous Defects.

revived the operation in Italy, using a flap taken from the arm. The provision of an inner lining was not sufficiently appreciated by the early surgeons

In the modern operation the rhinoplastic flap is commonly raised

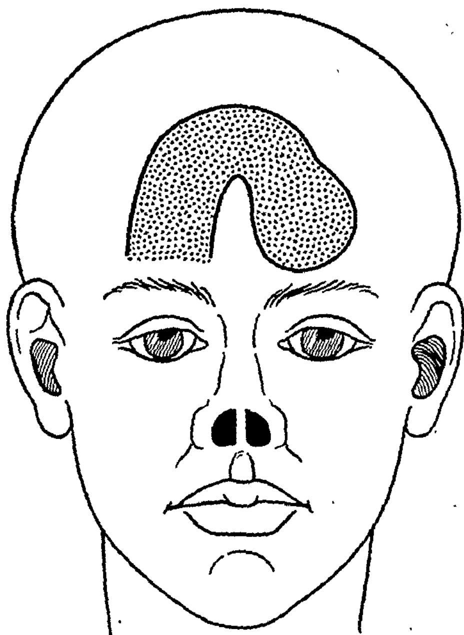


Fig. 88. To illustrate Pedicled Flap from Forehead to repair defect in Nose.

CHAPTER X

AMPUTATIONS

Modern methods: Provisional amputation; Final amputation; General technique; After-treatment; Sequelae.
Individual amputations: Below-knee; Above-knee; of Foot and Toes; Below-elbow; Above-elbow; Interscapulo-thoracic; of Hand and Fingers. Cineplastic amputations. Prostheses.

Experience in the surgery of warfare gained within recent years has led to considerable modification and simplification of the methods of amputating, with the result that many of the classical operations devised by the older surgeons are now chiefly of historical interest. This is due to the recognition that, apart from the saving of life, the chief object of the surgeon in amputating is to provide a stump that is capable of being adjusted to an artificial limb that will be the best functional substitute for the lost part, with the least possible deformity.

The planning of individual amputations to meet the requirements of the limb-maker and the designing and construction of artificial limbs have been intensively studied in different specialized hospitals by surgeons and technicians working in close co-operation. As a result, methods of performing major amputations at different levels have to a large extent been standardized, and, although there are individual preferences, those adopted at Queen Mary's Hospital, Roehampton, have been generally accepted.[1]

The best results are obtained when the surgeon and the limb-maker can co-operate throughout, if possible in planning the original operation, but always in the selection and fitting of the appropriate prosthesis, and in the instruction of the patient in the use of it.

Provisional Amputation.—In cases of exceptionally severe injury in which gross infection is inevitable, and also when the removal of the limb is called for on account of an infective condition apart from injury, a provisional or temporary amputation may be performed to tide the patient over the immediate shock and to allow of the effects of the infection being overcome sufficiently to permit of a final amputation being performed under more favourable conditions.

The technique of a provisional amputation differs from that of the final procedure in that the stump should be left as long as possible consistent with removing all the grossly damaged or infected tissue, and that free drainage must be provided by leaving the deep fascia

[1] We desire here to acknowledge our indebtedness to the writings of Mr. George Perkins, *Brit. J. Surg.* (1944), xxxi. 377.

from the forehead, but the procedure adopted is influenced by a variety of factors (Fig. 88) Other flaps employed are the acromio-pectoral, humeral, and the abdominal.

Partial defects of the tip or an ala may be repaired with free grafts from the rim of the ear, or with a pedicled graft from the forehead.

Face.—Repair of severe facial defects resulting from burns or gunshot wounds may require to be carried out in stages. It is to be borne in mind that symmetry is more important in facial repair than perfection of form (Fig. 89).

Pectoral flaps are usually employed, but free skin grafts may be useful.

Depression of the cheek may be remedied by inserting through a small opening a transplant of adipose tissue, due allowance being made for the subsequent shrinking of the graft.

A. B. W.

generally preferred to the use of a pylon as a means of moulding the stump.

As early as possible the patient should make voluntary contractions of the muscles of the stump, being instructed as to the groups of muscles that are most important for the control of the artificial limb to be fitted. Later he is made to *exercise* the muscles *against a weight* and pulley.

At the same time steps are taken to *exercise the joints* acting on the stump, by prescribing definite movements of a purposive nature that are calculated to improve control of the prosthesis to be worn. In this way the cerebral centres and the nervous mechanism actuating the muscles are gradually re-educated to adjust themselves to the altered conditions.

After the prosthesis has been applied under the guidance of the limb-maker, the patient is instructed in the use and care of the apparatus.

Sequelae of Amputations.—If the wound heals by first intention; if there is no redundance of soft tissue, particularly of subcutaneous fat, in the stump; and if the scar is not exposed to pressure or adherent to underlying tissues, the stump, as such, rarely causes trouble

In spite of precautions, however, troublesome sequelae sometimes occur, e.g.:

Infolding of the cicatrix forms a sulcus in which skin secretions accumulate and are liable to cause intertrigo and septic ulceration. In severe cases it may be necessary to excise the scar and resuture the skin.

Adherent Scar.—Adhesion of the scar to the underlying soft tissues interferes with the 'piston-action' of the stump within the socket of the artificial limb, and causes pain and tenderness from irritation of the sensitive nerve-bulbs. This results usually from failure to suture the deep fascia completely. It may become necessary to excise the cicatrix, or even to remove a portion of the bone and resuture the deep fascia.

A *spur of bone* sometimes forms at the end of a stump, and if it causes discomfort should be removed.

Tender Stump—This may be due to a variety of causes, the most important of which is the formation of neuromata at the ends of divided nerves, which if pressed upon by the prosthesis, or dragged upon as the stump moves within the socket or by the action of muscles in the stump, may cause severe pain. In exceptional cases it is necessary to expose the trunk of the affected nerve and divide it at a level high enough to remove the cause. In some cases tenderness in a stump is intractable to surgical treatment.

and skin unsutured. In other respects the procedure is similar to that of *a final amputation as described below.*

General Technique.—The following rules apply generally to all amputations, and to avoid repetition in the descriptions of individual operations only such modifications as are indicated will be mentioned.

Haemorrhage is controlled by means of a tourniquet, or in high amputations when this may be in the way of the surgeon, by digital compression or by temporary ligation of the main artery of supply.

Flaps.—The level at which the bone is to be divided having been determined, equal antero-posterior integumentary flaps are cut. These are semilunar in outline, of sufficient length to cover the soft tissues and bone, and include skin and deep fascia which are reflected in a single layer to about 2·5 cm (1 in.) below the level of bone section.

The *muscles* are divided transversely at this level, and after retracting they come to be at the level at which the saw is to be applied.

The *bone* is then sawn transversely flush with the retracted muscles.

Haemostasis.—To ensure primary union, and to avoid the formation of a haematoma in the wound, the arrest of bleeding must be complete. The main vessels and their larger branches are secured by forceps and ligature before the tourniquet is removed; and as many as possible of the smaller vessels that continue to bleed are secured by ligation or by forci-pressure

The *nerve-trunks* are divided along with the muscles, and need not be further disturbed

The *deep fascia* is identified as a separate layer and accurately sutured so that it forms a complete covering for the soft tissues and bone without being adherent to them.

The *skin* is sutured without tension and care is taken to avoid infolding of the edges

Drainage is unnecessary in most cases and is to be avoided if possible, but if the formation of a haematoma is feared, a drain may be introduced at the lateral angle of the wound, and retained for twenty-four to forty-eight hours, if the wound is dry.

The *dressing* is retained in position by a crêpe or domette bandage, with sufficient pressure to prevent oozing, and in such a way as to mould the stump into a conical shape. The stump may lie flat on the bed without the support of pillows or cushions.

After-treatment.—To prepare for the fitting of an artificial limb, the stump is gradually moulded into a conical shape by accurate *bandaging* from below upwards with the maximum pressure exerted over its end As the bandage soon becomes loose with the shrinking of the soft tissues, it has to be frequently renewed Bandaging is

by long extensor and short flexor flaps; Farabœuf's by antero-lateral flaps; and Bier's osteoplastic operation.

Amputations above the Knee.—In amputating between the knee and the hip, the stump should be designed to retain as much as possible of the insertion of the adductor muscles, as any lack of power to adduct the artificial limb adds greatly to the difficulty of balancing and of walking without a limp. As measured from the tip of the great trochanter to the end of the divided femur, the stump should be about 27 cm (11 in) long This will ensure that it has sufficient leverage, and that it remains securely in the socket of the artificial limb. To admit of a satisfactory knee-joint action being incorporated in the prosthesis, the end of the stump must be at least 7·5 cm. (3 in.) above the level of the knee-joint.

In high thigh amputations, if the stump is too short to remain in the socket, a 'tilting table' mechanism is introduced into the apparatus to enable the patient to sit with comfort. To admit of this at least 10 cm. (4 in.) of the femur must be left.

After disarticulation at the hip, it is difficult to fit any satisfactory prosthesis.

In amputations above the knee special attention is paid during the after-treatment to strengthening the adductor and extensor muscles by practising exercises against a weight and pulley

Formerly the stump of an amputation above the knee was intended to bear weight directly on its end, and to exert leverage on the prosthesis. Operations were therefore designed to provide a long stump, with a broad rounded end, and with the scar removed from the line of pressure on the posterior aspect. Classical examples of such operations are the *Gritti-Stokes amputation* just above the condyles of the femur, by a long extensor and short flexor flap, the patella being retained in the long flap, its articular surface shaved off, and the raw bone applied to the sawn end of the femur. A similar procedure was devised by *Carden* and modified by *Lister*, in which the patella was sacrificed *Disarticulation at the knee* was practised mainly as an emergency operation when speed and reduction of shock were important. The stump is quite unsuited to the fitting of an artificial limb

Amputations of the Foot

Amputations at the Ankle-joint.—Syme's Amputation.—The classical operation is that devised by James Syme (1842), by means of a single flap taken from the heel An assistant holds the foot at right angles to the leg, and the operator, standing at the lower end of the table, with his left hand grasps the posterior part of the ankle, with the thumb and forefinger respectively on the malleoli.

Individual Amputations

Whether amputation is called for on account of injury, infection, or new growth, the surgeon determines the appropriate operation, but the modern 'seat of election' largely depends upon the requirements of the limb-maker so that a stump can be formed to which he may fit an efficient prosthesis. When it is possible the limb-maker should be consulted on this point before the limb is removed, but in any case his requirements must be borne in mind.

The mere length of the stump is no longer considered all-important; it is enough that it includes sufficient of the insertions of the muscles that move the joint above, and is long enough to remain in the socket of the artificial limb when the joint is flexed to a right angle. An unduly long stump has the disadvantage of having a deficient circulation, with liability to suffer from cold and the development of chilblains and superficial ulcers.

The general technique described above is applicable to all major amputations above the level of the wrist- and ankle-joints. Such modifications as are necessary in individual operations are referred to in relation to each Amputations below the wrist and ankle are described separately.

Amputations of the Lower Extremity

Amputations below the Knee.—The stump should, if possible, measure about 13·5 cm (5½ in) from the level of the knee-joint to the end of the divided tibia; but 10 cm. (4 in.) may be sufficient. As the deep fascia is absent over the subcutaneous surface of the tibia, in making the anterior flap the periosteum in this area is divided and reflected with the skin Elsewhere the periosteum is divided with the bone. By making equal, semilunar, antero-posterior flaps a terminal transverse scar is produced, but if a slightly posterior scar is preferred, the anterior flap is made a little longer than the posterior.

To avoid the sharp edge of the divided tibia pressing on the face of the stump it should be bevelled by entering the saw obliquely a little above where it is intended to divide the bone, and after cutting for a short distance, withdrawing the saw and reapplying it at right angles about 2·5 cm (1 in.) lower down. The fibula should be sawn across about 2·5 cm. (1 in) higher than the tibia to prevent cross union between the bones. The interosseous membrane is divided transversely before the saw is applied

Pylons are not recommended as a means of moulding the stump into a conical shape. their only advantage is that their use may enable the patient to dispense with the use of crutches sooner.

This procedure has replaced such classic amputations as Teale's,

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Other Amputations in the Region of the Ankle.—Other amputations at the ankle-joint and in the tarsal region include:

Pirogoff's operation in which Syme's procedure is modified to the extent that in reflecting the heel-flap the posterior part of the calaneus is sawn off and brought into apposition with the raw surface

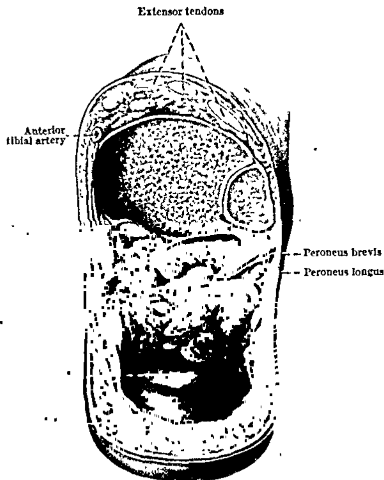


Fig 91. Amputation of Left Foot by Syme's Method.

of the tibia. This gives a good weight-bearing stump, but it is too long to admit of an ankle-joint mechanism in an artificial foot.

MacKenzie's operation, in which the flap is taken from the medial side of the foot, is useful in cases where the soft tissues on the lateral side have been severely crushed, for example, by the flange of a wagon, as occurs in railway shunters

In *Chopart's amputation* the anterior part of the foot is removed through the mid-tarsal joint; and in *Lisfranc's* through the tarso-metatarsal joints The flap is preferably taken from the sole where

The point of a strong-bladed knife is entered below the tip of the lateral malleolus, cutting down to the bone, and is carried slightly backwards and then across the sole to the corresponding point on the opposite side—that is, 1·75 cm. (½ in.) below and behind the tip of the medial malleolus (Fig. 90). If the heel is large and prominent, the backward inclination of the incision should be more decided. With the aid of the left thumb the heel-flap is dissected off the

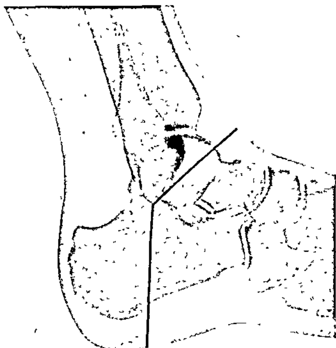


FIG 90 Incisions for Syme's Amputation

calcaneus by a series of strokes with the knife, made upon the bone and not upon the flap, until the insertion of the tendo calcaneus is reached; the tendon is now divided. The operator then grasps the anterior part of the foot with his left hand, forcibly points the toes, and joins the two ends of the incision made for the heel-flap by the shortest route across the dorsum. He then opens the ankle-joint from the dorsum, remembering that the articulation is 1·75 cm. (½ in.) proximal to the tip of the medial malleolus, and, dividing the lateral ligaments, completes the disarticulation. If the articular surfaces of the tibia and fibula are diseased, the lower ends of these bones are cleared and removed with the saw, if not, merely the projecting points of the malleoli are removed, so that they will not bear unduly on the heel-flap (Fig. 91). The dorsalis pedis is secured in front, and the two plantar arteries on the medial side of the heel-flap.

it shall be long enough to remain within the socket of an artificial limb, and admit of a wrist-joint mechanism being introduced into the prosthesis.

The best length of stump for these purposes is about 17 cm. (7 in.) as measured from the tip of the olecranon to the end of the divided ulna. The shortest admissible length is 2·5 cm. (1 in.) below the prominence formed by the insertion of the biceps tendon

In sawing the bones, the radius, being a movable bone, should be divided first while it has the support of the fixed ulna. The interosseous membrane is divided transversely before the saw is applied.

Formerly stress was laid upon securing as long a stump as possible and retaining pronation and supination, but it is found that with a modern prosthesis with a wrist-joint mechanism the amount of rotation of the forearm is negligible. The various plans for securing additional length of stump and preserving pronation and supination, by circular, elliptical, or racket-shaped incisions, have been replaced by the making of equal antero-posterior flaps (p 198)

Disarticulation at the Elbow-joint is not favoured. The stump is too long and too heavy, and its bulbous end prevents the introduction of an internal elbow mechanism and adds to deformity.

Amputations above the Elbow.—To admit of the fitting of an elbow-joint mechanism in the prosthesis, and to ensure that the stump remains securely in the socket during movement, a length of 20 cm. (8 in.) measured from the acromion process to the end of the humerus is desirable. If a shorter stump is inevitable, it must contain at least 2 cm (1 in) of the humerus below the level of the anterior axillary fold. In amputating at or close to the shoulder-joint, the retention of even 2·5 cm (1 in) of the humerus is of advantage.

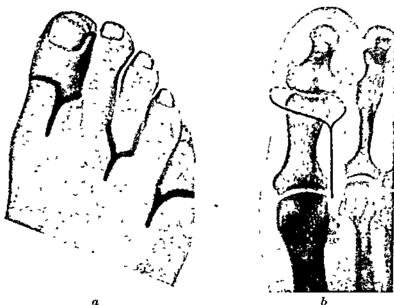
In the after-treatment it is important to educate the patient to adjust the movements of the muscles of the shoulder girdle in the control of the artificial limb

In high upper-arm amputations the control of haemorrhage raises problems Any form of tourniquet or of steel skewer transfixing the limb is in the way of the surgeon and is uncertain in its effect. In most cases digital compression of the subclavian against the first rib by a reliable assistant is satisfactory; or the brachial vessels may be isolated and secured between the fingers and thumb before being divided, as in Spence's method of amputating at the shoulder. In some cases it is advisable to ligate the main vessels above the clavicle as a first step in the operation.

Interscapulo-thoracic Amputation (Berger's Operation).—The whole upper extremity along with the scapula is occasionally removed for malignant disease, for acute gangrene, or for severe injury.

the tissues are vascular and the skin is accustomed to pressure. There is a tendency after both operations for the stump to be pulled into the equinus position by the unopposed action of the tendo calcaneus unless special precautions are taken

As partial amputations are usually performed for trauma, the flaps must be made from the soft tissues that are least damaged. They generally yield good sound stumps which can be made more useful by transplanting or suturing opposing tendons



a b

FIG 92. Amputation of Toes at Metatarso-phalangeal Joint by Racket Method.

(In the great and little toes the handle of the racket is placed nearer the middle line of the foot)

Amputations of Toes.—It is seldom advisable to perform partial amputation of any one of the four *smaller toes*, as the stump is so short as to be useless, and is liable to become dorsi-flexed so that it is pressed upon by the shoe

A racket-shaped incision is made, beginning over the metatarso-phalangeal joint (which is about an inch above the level of the web) and encircling the toe at the level of the web (Fig 92).

The ball of the *great toe*, being one of the legs of the tripod on which the weight-bearing function of the foot depends, should be preserved as far as possible

AMPUTATIONS OF THE UPPER EXTREMITY

Amputations below the Elbow.—As the stump is not designed to bear weight but to ensure mobility, the main consideration is that

amputations give place to trimming of the soft parts, such bone as must be sacrificed being shelled out of its periosteum.

The head of the metacarpal of the thumb being much larger than those of the other fingers, the flap must be proportionally more generous.

It is desirable to save the base of the proximal phalanx, with the tendons attached to it—the extensor brevis, the abductor brevis, the adductor, and the flexor brevis—as the preservation of these attachments adds greatly to the usefulness of the hand. The mobility of the stump may be further increased by stitching the tendons over the end of the bone.

When *fingers* are involved it is important to amputate through phalanges rather than through a joint, at a level which preserves the insertions of their tendons. If the divided ends of the flexor and extensor tendons are stitched to one another over the end of the phalanx the patient can control the movements of the stump. The tendons must be cut as long as possible, and the finger should be semiflexed while they are being divided so that they may be equal in length It is desirable to close the sheaths, so that should infection occur the risk of tenosynovitis may be diminished.

Immediate amputation is advisable when the tip of a crushed finger is ischaemic, when there is extensive loss of skin, when the flexor tendons are divided, or when there are compound fractures of the middle or proximal phalanges, or shattered joints. A finger ankylosed in extension usually calls for amputation.

If possible the base of a terminal phalanx should be retained. If the index finger must be amputated proximal to the terminal phalanx it is better to amputate the whole finger and to cut obliquely through the metacarpo-phalangeal joint; the head of the metacarpal should be removed

It is essential that the bone is well covered with healthy skin, and that the scar is on the dorsal aspect.

Cineplastic Amputations.—Attempts have been made by plastic operations to utilize muscles in a stump in such a way that they are made to subserve definite functions by activating mechanical appliances attached to the stump. These operations, however, are more ingenious than useful and have been abandoned

Prostheses.—A consideration of the construction, fitting, and care of the various forms of prosthesis used after different amputations is beyond the scope of this book. A detailed description of these is available in *Artificial Limbs and their Relation to Amputations* (1939), issued by H.M. Stationery Office, price 3s. net.

A. M.

An incision (Fig 93) is made along the entire length of the clavicle; the bone is divided, or its middle third resected, to enable the main vessels to be ligated, and the trunks of the brachial plexus to be blocked with procain, before being divided. With the arm in the abducted position an incision is then carried from the midpoint of the clavicular incision over the front of the shoulder to the anterior axillary fold, across the axilla to the posterior fold, and thence to the inferior angle of the scapula.

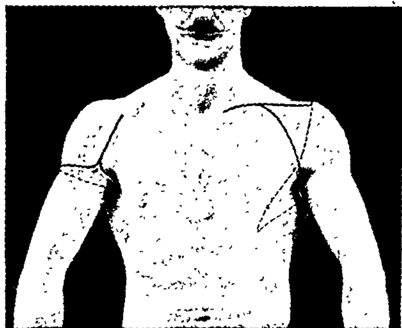


Fig. 93. Incisions for Disarticulation of Right Shoulder, and for Interscapulo thoracic Amputation—Left.

The pectoral muscles, and the muscles attached to the scapula, are divided, and any infected glands removed. After all bleeding has been arrested, the wound is closed and drained through a stab wound in the posterior part of the flap

Amputation through the Wrist.—The hope of retaining the movements of pronation and supination by amputating through the wrist-joint is largely illusory, as the fitting of a prosthesis prevents [illegible] movements being carried out, and moreover the limb maker can

mended.

Amputations of Thumb and Fingers.—In injuries of the *thumb* it is important to save as much tissue as possible to furnish something against which the other fingers or stumps can be opposed. Formal

Infective Conditions.—*Suppurative cellulitis* usually occurs as a complication of an infected wound, and is accompanied by oedema of the overlying integument, even before fluctuation can be detected. If the oedema does not rapidly subside after removal of stitches and purification of the wound, linear incisions parallel to the main arteries should be made wherever bogginess is detected.

A superficial *abscess* usually remains localized, and is treated by simple incision and drainage. If pus extends under the epicranial aponeurosis and spreads widely in the subaponeurotic space, several incisions may be necessary to secure drainage.

Superficial cario-necrosis, whether pyogenic or tuberculous, is dealt with by excising the sinus which is usually present, scraping the osseous lesions with a sharp spoon, and treating the wound by the open method. The separation of a superficial sequestrum can be hastened by making small drill-holes down to the diploe If the whole thickness of the skull is involved, the area of infected bone is removed with rongeur forceps.

Sebaceous Cysts or Wens.—The hair is shaved for a distance of 5 cm. (2 in) from the margin of the wen, a local anaesthetic is injected into the fibro-fatty layer of the scalp where the nerves ramify, and an incision is made through the integument over the convexity of the swelling. If the cyst is not adherent to the skin it can usually be shelled out by blunt dissection. If its wall is torn in the process, the cyst should be slit freely open, its edges caught with artery forceps, and the cyst twisted out. Pressure arrests the bleeding, and the wound is closed with fine sutures.

When the cyst is large and the integument over it is thinned out and adherent, an elliptical portion of skin should be removed along with it This should also be done in fistulous or ulcerated wens

If the wen is inflamed, and the whole cyst wall cannot be dissected away, the cavity is painted with pure carbolic acid to destroy any portion of the lining membrane that may be left, filled with penicillin cream, and treated by the open method. If necessary, the remains of the cyst may be excised later.

When a large number of wens have to be dealt with, a general anaesthetic is preferable

Dermoid Cysts.—These cysts develop in the deeper planes of the scalp and are firmly attached by a fibrous pedicle to the pericranium, to the bone, or, if there is a defect in the bone, even to the dura mater.

When situated over the superciliary ridge, the commonest position, an incision is made parallel to the curve of the eyebrow, the cyst dissected out entire, the haemorrhage arrested by forci-pressure or

CHAPTER XI

OPERATIONS ON THE SCALP

Anatomy Injuries. Infective Conditions Sebaceous Cysts. Dermoid Cysts Haemangioma. Cirsoid Aneurysmal Varix. Epithelioma and Rodent Ulcer Cephalocele.

Anatomy.—The integument of the scalp is more dense than that of the rest of the body owing to the sparseness of the subcutaneous fat, and it is intimately united to the epicranial aponeurosis by a network of firm fibrous tissue. This accounts for the profuse bleeding from wounds of the scalp, the cut ends of the divided vessels being unable to contract and retract to bring about the natural arrest of haemorrhage, and also for the difficulty of controlling the bleeding-points with forceps and securing them with ligatures. Between the epicranial aponeurosis and the pericranium is a comparatively open space in which extravasated blood or inflammatory products can rapidly accumulate and spread over a wide area

The arterial supply to the parietal and occipital regions is from the external carotid through its temporal, posterior auricular, and occipital branches; the frontal area is supplied from the internal carotid through the supra-orbital branch of the ophthalmic artery The venous return is by way of the frontal, temporal, and occipital veins, and the various emissary veins that communicate with intracranial sinuses

The nerves of sensation are the supra-trochlear, supra-orbital, and auriculo-temporal branches of the trigeminal nerve, the muscles are supplied by the facial. The lymph vessels drain into the parotid, occipital, mastoid, and submandibular groups of glands The scalp contains numerous sweat and sebaceous glands

Injuries.—In superficial *scalp wounds*—the ordinary 'cut head'—after the surrounding area has been shaved and the wound purified, the edges are brought together with interrupted through-and-through or with figure-of-eight sutures If the epicranial aponeurosis is involved, its edges should be apposed with a separate row of interrupted stitches of fine silk.

When a *haematoma* has formed under the epicranial aponeurosis and the clot has liquefied, the absorption of the fluid can be hastened by aspiration. This applies also to the cephalhaematoma of infants.

When portions of the scalp have been completely destroyed or avulsed, the defect may be covered with skin grafts applied to the granulating surface or by a plastic operation

Complete avulsion, which usually includes the epicranial aponeurosis, and sometimes the pericranium, calls for more extensive plastic operations

When the skull has been bared extensively, and if asepsis is assured, a free skin graft applied immediately may prevent the occurrence of osteomyelitis.

to the cranial cavity if possible; otherwise it may be excised, as it is seldom of functional importance.

The greater part of the collapsed sac is then removed, enough being preserved, however, to admit of its being closed with interrupted silk sutures to avoid leakage of cerebrospinal fluid. The skin flaps are then sutured in position.

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torsion, and the wound closed with fine sutures. Local anaesthesia is employed.

The removal of a dermoid cyst of the mastoid region is often difficult, owing to firm adhesions on its deep aspect. A general anaesthetic is usually necessary.

Haemangioma.—Haemangiomas of the scalp that are not suitable for treatment by radium or carbon dioxide snow may be excised by carrying an incision round the growth sufficiently beyond the margin to avoid cutting into the tumour tissue. The haemorrhage can be controlled by forci-pressure and by ligation of the larger vessels.

Cirsoid Aneurysmal Varix, when circumscribed and of limited size, may be treated by excision. The bleeding, which may be formidable, is controlled by an elastic tourniquet applied horizontally round the head. The afferent arteries are then exposed and ligated, and the plexus of anastomosing vessels excised.

Another method consists in throwing down a horseshoe-shaped flap of scalp including the vascular mass, clamping the pedicle of the flap which contains the feeding arteries, securing these seriatim, dissecting out the aneurysm from the deep aspect of the flap, and, after securing all bleeding-points, replacing the flap and stitching it in position

Epithelioma and Rodent Ulcer.—The skin having been shaved and disinfected, two curvilinear incisions are carried round the growth in a direction at right angles to that in which the scalp glides most readily, and 1·75 cm ($\frac{1}{2}$ in.) beyond its margin. This may be done with the scalpel, or preferably with the diathermy knife If the growth is confined to the soft parts the incision reaches the pericranium, if it is adherent to the bone the external table of the skull is removed with a chisel, if the diploe is implicated the whole thickness of the skull must be removed

The raw surface may be covered by local rotation flaps or by free skin grafts. The associated lymph glands should be removed at the same time

Cephalocele.—*Congenital Cephalocele*—The thin, naevoid, or ulcerated portion of skin over the most prominent part of the cephalocele should be removed by crescentic incisions carried round it. Integumentary flaps which will admit of complete closure are [illegible] and reflected so as to expose thoroughly the sac and the [illegible] the [illegible] lden

displacement of the brain and respiratory embarrassment The sac is then opened

When the protrusion includes brain matter this should be returned

Bleeding can be controlled by an assistant grasping the lip between the fingers and thumb.

Unilateral Hare-lip.—The operation is carried out when the baby is 10 lb. in weight and thriving. *Concave incisions* passing through the free edges are made (Fig. 94). Interrupted muco-muscular stitches of catgut are introduced from the buccal side. When the skin edges are brought together, a vertical scar is left. The skin stitches of fine silk are removed on the fifth day.

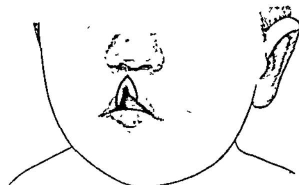


FIG. 94. Unilateral Hare-lip, Nelaton's Incision.



FIG. 95 Operation for Unilateral Hare-lip by Rose's Method.

When the notch extends into the nostril, Rose's operation (Fig. 95) is suitable As the nose is usually flattened, it is necessary to begin by *separating the lip from the alveolus on the lateral side of the cleft.* In doing this the knife or scissors should be kept close to the bone, and it may be necessary to carry the mobilization as far as the infra-orbital foramen, or even to separate the ala by making an incision around the nostril. The edges of the cleft are then pared by crescentic incisions till the muco-cutaneous junction is reached, when a small flap is made on each side at the free margin.

When the gap is wide and the edges asymmetrical, the longer and more oblique edge is pared in a straight line, and from the shorter and more vertical edge a good thick flap is cut with its base left attached at the lower red border of the lip (Mirault). This flap is then turned down and brought across the rawed surface on the

CHAPTER XII

OPERATIONS ON THE FACE, MOUTH, AND TONGUE

Anatomy. Congenital Deformities. Injuries. Infections. Tumours. Operations on Salivary Glands.

Anatomy.—The skin of the face is exceptionally mobile owing to the layer of loose connective tissue on its under surface and to the muscles of expression being directly inserted into it. It is rich in subcutaneous and sweat glands, and owing to the laxity of the subcutaneous tissue is specially liable to oedematous swelling in inflammatory affections. It is richly supplied with blood through the facial and temporal arteries, which anastomose freely across the middle line. These facts favour the healing of wounds of the face and admit of extensive plastic operations being carried out successfully. Infections in the vicinity of the naso-labial fold of the upper lip ('dangerous area') are liable to give rise to thrombo-phlebitis which may spread to the cavernous sinus by way of the valveless angular vein. Sensation is supplied through the *trigeminal nerve*; the supra-orbital and supra-trochlear branches of the ophthalmic division supplying the forehead; the infra-orbital nerve, from the maxillary division, supplying the lower eyelid, the side of the nose, part of the cheek, and the upper lip; and the buccal, mental, and auriculo-temporal branches of the mandibular division supplying the remainder of the cheek, the skin over the mandible, and the lower lip.

The muscles of expression are supplied by the *facial nerve*, which, after leaving the stylomastoid foramen, turns forwards and passes through the deep part of the parotid gland, within which it divides into numerous branches, which as they leave the gland radiate towards the muscles. The main trunk of the nerve crosses the neck of the mandible opposite the lobule of the ear, about a finger's breadth below the zygomatic arch.

The *parotid gland*, enclosed in its fibrous capsule, occupies the space between the mastoid process and the mandible, extending forward on to the surface of the masseter muscle, downwards as far as the digastric muscle and upwards to the zygomatic arch.

The *parotid duct* emerges from the anterior border of the gland less than a finger's breadth below the level of the zygomatic arch, and after crossing the masseter muscle pierces the buccinator and opens into the mouth opposite the second upper molar tooth.

CONGENITAL DEFORMITIES—HARE-LIP AND CLEFT PALATE

Hare-lip.—The appropriate operation varies according to the extent of the gap in the upper lip, the amount of hypoplasia of the soft tissues, and the degree of flattening of the nose.

To obtain a satisfactory result, the raw surfaces should be made as broad as possible, the edges brought together without tension, and the muco-cutaneous junction sutured accurately. The tendency to retraction (eversion) of the red margin is reduced if the line of the skin suture is stepped and not quite linear.

been modified and improved in various ways to suit the conditions in individual cases.

The operation now favoured aims at obtaining a closer approximation of the soft palate to the posterior wall of the pharynx.

Incisions are made on each side to expose the hamular process around which the tensor palati muscle hooks, the process is fractured, and the halves of the soft palate fall towards the middle line. The edges of the cleft are pared (Fig. 97 *a*, *b*), and V-shaped flaps, including the greater palatine artery, are then cut in the hard palate,

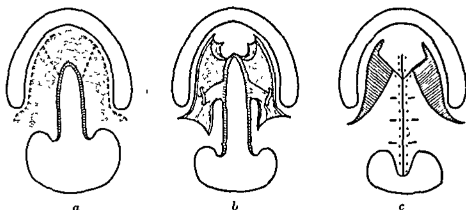


FIG 97. Stages in Operation for Cleft Palate.
a Incisions to expose hamular processes
b. V-shaped flaps formed and edges of cleft pared
c. Cleft closed

and are detached from the posterior edge of the hard palate and pushed back, thus converting the V-flaps into a Y (Fig 97 *c*).

When the nasopharyngeal opening is wide, a transverse incision is made at Passavant's ridge on the posterior pharyngeal wall, just below the level of the anterior arch of the atlas, opposite the uvula (Wardill) The incision in the pharyngeal fold is sutured vertically, and the nasal mucous membrane, the muscles, and the oral mucous membrane of the palate are separately sutured (Fig. 98).

Palate Obturators.—When permission for operation has been refused or surgical interference unsuccessful, the cleft can be closed by a vulcanite or acrylic obturator constructed as part of a denture. Palate obturators are fitted by dental surgeons.

Speech Therapy.—Following operative treatment, patients must receive speech training to assure the development of palato-pharyngeal sphincter control.

Injuries.—In closing simple superficial wounds of the face without loss of tissue, to avoid a disfiguring scar and stitch marks, the subcutaneous tissue is approximated with interrupted sutures of

opposite edge and stitched in position, and the remainder of the wound closed with sutures (Fig. 95).

Bilateral Hare-lip.—The operative procedures for double hare-lip are influenced by the size, shape, and position of the premaxilla and prolabium. An attempt should always be made to save all of these structures

When the premaxilla retains its normal position the edges of the prolabium are pared in a rectangular V-shaped fashion so that it may form the central part of the new lip. The edges are then pared by straight incisions (Fig. 96). To overcome the flattening of the nose, and to admit of the parts being brought together without tension,



FIG. 96 Operation for Double Hare-lip with separate Premaxilla.

the mucous membrane of the lip must be freely separated from the maxilla, and it may even be necessary to carry an incision round each ala of the nose to effect this The lower parts of the lateral margins of the clefts are then brought together in the middle line and sutured with fine silk, after which the remaining raw surfaces are approximated. No attempt should be made to bring the prolabium down to the free margin of the new lip, as this tends to depress the tip of the nose.

When the premaxilla projects in front of the lateral portions of the maxillary arch, the soft tissues of the lip are freely mobilized from the maxilla to allow approximation to the prolabium. In a matter of a few weeks the constant pull of the repaired lip is found to have been sufficient to bring about replacement of the premaxilla. Active surgery to reduce this part is never necessary.

Cleft Palate.—Opinions differ as to the age at which an attempt to close the cleft by operation should be made The modern tendency is to operate early in the second year when the child is better able to stand it, and the habit of speaking through the nose will be less likely to be acquired.

The objects of the operation are to secure a mobile soft palate which will shut off the nasal from the oral cavity, with accurate union of the palatal muscles in the middle third. This implies that there is a general pushing back of the whole palate

The classical operations are those of Langenbeck, but they have

more incisions may be made at the lower reflection of the conjunctiva, a fine dissector or sinus forceps passed into the oedematous tissue, and a rubber drain inserted. If pus has formed larger incisions are required and it may be necessary to incise the eyelid to establish efficient drainage.

Tumours.—Non-malignant tumours are treated by excision.

Malignant epithelial tumours are usually at first of the basal cell type, when they respond to radiation; but they are liable to assume squamous cell characters and are then less amenable to radiation.

When radiotherapy is not available, the tumour is removed, preferably with a diathermy knife, by cutting well beyond its margin and clear of all deep attachments, removing, if necessary, any portion of bone that is invaded. If the wound cannot be completely closed after undercutting, a free skin graft can be applied to the raw surface, or a plastic repair can be undertaken later. The associated lymph glands are treated by radiation or by excision.

Epithelioma of Lower Lip—The lower lip is a favourable site for the use of radiotherapy.

When operation is necessary in limited growths, a V-shaped or a rectangular incision is made through the whole thickness of the lip, cutting well beyond the margin of the growth. The mucous membrane is brought together with catgut, and the skin with horsehair sutures.

When the growth has extended towards the angle of the mouth and has invaded the cutaneous part of the lip, the incision should be sufficiently wide to include the lymph channels leading to the submental and sub-mandibular lymph glands, and to admit of these glands being removed.

Some degree of plastic repair is necessary to re-form the mouth, for example, by making a collar incision in the natural fold of the skin from one sternomastoid to the other, and dissecting widely enough to expose the lymph glands, which are removed along with the sub-mandibular salivary gland. It is sometimes necessary to expose and remove the deep cervical lymph glands also. In the dissection care is taken to avoid the hypoglossal nerve as it reaches the tongue beneath the posterior belly of the digastric. After the main wound has been sutured, a stab drain is introduced at the most dependent part of the wound on each side.

Syme's plastic operation was designed for extensive cases. After removal of the disease by elliptical incisions which leave the central portion of the chin intact, incisions are made in the neck and flaps raised by undercutting to form a new lip. These are pulled up and sutured, and are fixed to the central portion of the chin which has not been disturbed and serves to give them a fixed basis of support.

fine catgut, and the skin edges brought together with fine silk stitches, placed as close as possible to the edge of the wound. The stitches can be removed in from three to five days.

In contused and lacerated wounds contaminated with gross dirt or foreign bodies, like gunpowder, small shot, fragments of glass, &c., the grossly damaged tissue is excised, and foreign bodies are removed as far as possible. If the wound cannot be closed completely and if asepsis is assured, gaps may be covered at once with skin grafts, or with small pedicled flaps taken from adjacent healthy tissues.

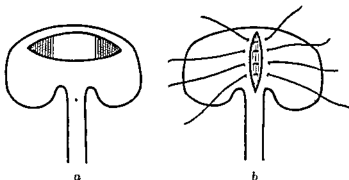


FIG 98 *a*. Transverse Incision in Posterior Pharyngeal Wall. *b* Incision Closed Vertically

Fractures.—Facial injuries are frequently complicated by fracture of the maxilla, the zygomatic arch, or the zygoma, or the wall of the orbit Displaced fragments should be moulded into position as far as possible and steps taken to retain them there.

If displacement of the zygomatic arch persists and the movements of the lower jaw are interfered with, it may be necessary to make an incision in the temporal region and lever the displaced fragments into position.

When diplopia, or other disturbance of vision, is present, due to displacement of the floor of the orbit, the bone may be moulded into position by packing the maxillary antrum through an opening in the anterior wall as in the Caldwell-Luc operation (p. 229).

Plastic operations for the effects of severe facial injuries are referred to at p. 196.

Infections.—Boils, carbuncles, and other acute infective lesions frequently occur on the face, and when they are in the region of the upper lip are especially liable to spread to the intracranial venous sinuses, to prevent which it is sometimes advisable to ligate the angular vein.

For *cellulitis of the orbit,* to relieve pressure on the globe and to anticipate the spread of suppuration in the connective tissue, one or

between ligatures. The edge of the sternomastoid is then defined, and if invaded by tumour a portion of the muscle is removed. The fingers are now passed under the mass to raise it from the posterior belly of the digastric to expose the external carotid artery, which is secured and divided between ligatures. The temporal fascia is divided above the tumour, and the superficial temporal vessels are secured and cut.

In separating the deep connexions the growth may be found attached to the capsule of the joint, a portion of which must be removed. Just behind the joint the external carotid divides into the superficial temporal and maxillary arteries, both of which must be secured. If the tumour is adherent to the cartilage of the external acoustic meatus or to the mastoid process, portions of these must also be removed.

Parotid Fistula.—A fistulous opening from the *glandular substance* of the parotid, following, for example, the draining of a parotid abscess, may eventually heal, but as a rule is very intractable to surgical treatment and may persist for many weeks or even months. Many methods of treatment have been tried, but with only very limited success

If the *parotid duct* has formed a fistulous connexion with the surface it may be induced to heal by excising the fistulous track, and after identifying the duct, passing a silk or fine wire thread along it till it emerges through the normal orifice into the mouth. The outer end of the silk is now threaded on a round needle and passed through the wall of the duct and then through the buccal mucous membrane near the normal orifice. The two ends of the silk now projecting into the mouth are knotted together, and as the thread ulcerates out a new exit for saliva into the mouth is established. The external wound is sutured.

If this procedure fails, the method devised by Chubb is recommended. A probe is passed backwards along the duct. A circle of skin of 1-cm ($\frac{1}{2}$-in.) diameter is cut around the fistulous opening and is raised up in continuity with the duct, in which the probe serves as a guide. A stab wound is then made through to the buccal surface, and the button of skin with the duct leading to its centre is drawn into the mouth where it is held by one or two catgut sutures. The wound on the skin surface is sutured

Calculus in Stenson's Duct is preferably removed by an incision through the buccal mucous membrane. The duct may be slit up and the stone shelled out with a small spoon, or the incision may be made directly over the stone It is not necessary to repair the duct

Sub-mandibular Calculus may be in the gland or impacted in the duct. If there is no infective complication, simple removal of the

The raw surfaces in the neck are easily covered by undercutting the skin.

Operations on the Salivary Glands

In operating for a *parotid abscess* care is taken not to injure branches of the facial nerve or Stenson's duct. A small vertical incision is made just in front of the lobule of the ear, the capsule of the gland is perforated with sinus forceps, which are pushed in till pus is reached. A dental-rubber drain is then introduced.

Tumours.—The common *non-malignant* ('mixed') tumour of the parotid is, in its early stages, encapsulated, and can be shelled out of the compressed salivary tissue surrounding it. An incision, sufficiently long to ensure free exposure, is made over the most salient part of the swelling, parallel to the main branches of the facial nerve, and the growth is shelled out Contractions of the facial muscles warn the operator to avoid the branches of the facial nerve.

For larger growths a vertical incision is made in front of the ear and a skin flap is reflected forward to give freer access. By recognizing the lowest branch of the facial nerve as it emerges from the lower pole of the parotid and tracing it and its chief branches to their distribution, injury to the nerve can be avoided. If the tumour is soft and vascular the capsule should be removed after its contents have been shelled out

Malignant Tumours.—A malignant tumour calls for removal of the entire parotid gland and of any of the adjacent structures to which the growth has spread. The facial nerve must be sacrificed. The incision employed depends on the size and disposition of the growth, but it must be planned to give access to the outlying parts of the gland, and to permit of the control of haemorrhage.

These indications are usually met by a ⊣-shaped incision, the vertical limb of which begins at the apex of the mastoid, and passes along the anterior edge of the sternomastoid as far as the level of the upper border of the thyroid cartilage, the horizontal limb being carried over the most salient part of the swelling. The two flaps thus delimited are reflected and held apart. Any portion of skin infiltrated by the tumour should be removed Kocher recommended an incision beginning on the temple, two fingers' breadth above the temporal process, and running vertically downwards in front of the tragus as far as a point on the anterior border of the sternomastoid, two fingers' breadth below the angle of the jaw

The tumour is exposed by incising the deep cervical fascia, and its lower and anterior borders are defined and separated, the transverse facial artery and the parotid duct being divided On reaching the posterior part, the external jugular vein is exposed and divided

If the cyst projects towards the submandibular region and is of considerable size, it should be removed through an external incision parallel to the mandible over the most prominent part of the swelling. After the integument is divided, the mylohyoid muscles are separated and the cyst excised, if possible without opening into the mouth. The wound is then closed without drainage.

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stone through an incision over it is sufficient. When infection is present it is best to remove only the stone, and to excise the gland later if necessary.

Operations on the Tongue

Anatomy.—The muscular substance of the tongue is divided into two lateral halves by a median fibrous septum across which there is practically no anastomosis of blood- or lymph-vessels. Each half is supplied by a lingual artery: the pharyngeal or posterior part by the dorsalis linguae branch, and the buccal or anterior part by the deep branch which, as it approaches the tip, lies under the mucous membrane nearer the under than the upper aspect of the tongue.

The hypoglossal nerve supplies the muscles of the tongue. The lingual branch of the mandibular nerve accompanied by the chorda tympani branch of the facial nerve supplies the anterior two-thirds with common and gustatory sensation, the posterior third being supplied by the glossopharyngeal nerve. The lymph-vessels of the anterior two-thirds of the tongue drain into the submental and submandibular glands, and these in turn into the deep cervical group along the internal jugular vein. The vessels of the base converge into several large trunks which pass out behind the tonsils and drain directly into the deep cervical glands In malignant diseases of the tongue metastases occur in these glands, particularly in one which lies in the angle between the internal jugular and common facial veins.

Tumours of Tongue.—*Papillomatous* or *epitheliomatous* growths, if small and limited to the surface of the tip or lateral margin of the tongue, may be removed by cutting out a wedge-shaped portion wide of the tumour, after the tongue has been pulled well out of the mouth by a silkworm thread passed through its substance. The resection is done with knife, scissors, or diathermy needle. The wound in the tongue is closed loosely with catgut sutures.

Carcinoma

Treatment by Radiotherapy.—Radiotherapy, by X-rays or radium, has to a large extent displaced operative treatment for squamous cell carcinoma of the tongue The details of these methods are not matters for a textbook of operative surgery.

Operations on the Floor of the Mouth

A Sublingual Ranula which projects towards the buccal cavity can usually be excised through the mouth With the head hanging over the end of the table an incision is made through the mucous membrane over the swelling, and the whole cyst dissected out. If any portion of the wall cannot be removed, it is swabbed with a solution of chloride of zinc (40 grains to the ounce) and the cavity packed with gauze and allowed to heal by granulation.

is sutured without drainage. Over a period of seven days, 4,000 units of penicillin a day are instilled directly into the area through a fine tube brought out through a separate stab incision. The main advantage of this operation is a considerable shortening of a long and tedious illness, but its risks, which are considerable, must be balanced against the more conservative treatment of allowing an involucrum to form, and removal of sequestra as they separate. The results following surgical resection of diseased bone in the mandible prior to the formation of the involucrum have not hitherto been encouraging, but the use of penicillin appears to permit more radical treatment.

Impacted and Unerupted Teeth.—Removal of impacted third mandibular molars may be an operation of considerable difficulty, and attention to certain details is important.

X-ray examination in two planes is desirable: (*a*) lateral view—to define the relationship to the tooth in front; (*b*) antero-posterior view—to define the buccal or lingual deviation in the case of lower molars, and the position inside or outside the dental arch of teeth in the upper jaw.

Impacted Third Mandibular Molar.—A dental prop is inserted between the molar teeth of the opposite side, and the buccal pharynx is packed off with gauze which has been wrung out of liquid paraffin. A tablespoon with the handle bent at a right angle is placed between the tongue and the dental ridge. With the index finger the retromolar triangle of the ascending ramus is located, and the muco-periosteum is incised 2 cm. (¾ in.) behind and above the second molar. The incision is carried down immediately lateral to the medial margin of the descending ramus as far as the second molar, and then curved outwards to the junction of the buccal sulcus and cheek. The triangular flap thus defined is raised with a sharp periosteum elevator, and retracted with a blunt rake. Sufficient overlying bone is removed with chisels and gouge or dental drills to allow the tooth to be displaced. In horizontal impactions at least half of the crown, and the whole length of the root, should be exposed. A pointed elevator placed between the crown and the outer plate is used to displace the tooth in an upward and backward direction. The fulcrum of this lever should always be the outer bone wall, and not the second molar. Undue force should not be used as the angle of the mandible is easily fractured. Splitting the tooth by a sharp blow of the chisel placed on its neck (which corresponds to the amelodental junction) [illegible]
in tw[illegible]
and [illegible]
on the inner side.

Fractures of Maxilla and Mandible.—The co-operation of the

CHAPTER XIII

OPERATIONS ON THE JAWS

Pre-operative Care. Acute Dento-alveolar Abscess. Osteomyelitis Impacted Teeth. Fractures. Bonegraft. Epulis. Dental Cyst. Resection of the Mandible. Fixation of the Mandible.

Pre-operative Care.—In operations on the jaws the hygiene of the mouth is of primary importance; if any marginal infection of the gums is present, the co-operation of the dental surgeon should be enlisted to scale and clean the teeth, and an astringent mouthwash should be brushed on the gums with a tooth-brush. In more severe infections, including Vincent's angina, penicillin pastilles will rapidly reduce the bacterial content of the mouth.

At frequent intervals after operations, and during the treatment of fractures, a Higginson's syringe with a metal cannula should be used to irrigate the mouth. A dessertspoonful of sodium bicarbonate dissolved in a pint of water is a satisfactory lotion; it should be used as hot as can be borne.

Dento-alveolar Abscess.—In the acute stage removal of the tooth involved is the correct procedure, provided it allows the free escape of pus If this does not follow, an intra-oral incision should be made into the swelling Abscess in relation to impacted or unerupted third mandibular molars should be incised. When the acute infection has subsided, the tooth should be dissected out

Chronic Osteomyelitis.—Operation for the removal of sequestra of the alveolar process is best carried out through the mouth. The mouth is opened with a gag, and the muco-periosteum is incised sufficiently widely to expose the affected segment of bone; sequestra are removed and diseased bone is gouged or scraped away. The cavity is then packed with vaseline gauze and the mouth kept sweet by frequent washing with antiseptic lotions.

Mowlem has advocated radical surgery in osteomyelitis of the mandible, after the initial acute stage has subsided and the extent of the disease can be determined. The bone is exposed by an incision along its lower border, and the diseased area removed subperiosteally. 'The lower margin of the jaw—which is dense cortical bone possessing a poor blood supply, and therefore a poor resistance to infection—is first removed, and then the outer plate is cut away to expose the affected area. Excision is continued until nothing but bleeding healthy bone is left. The defect as a whole is saucerized so that, after any mucosal defects have been closed, the soft tissues of the cheek collapse into, and obliterate, the resultant cavity.' The wound

between the loops may be used to reduce any displacement which cannot be moulded manually, and replaced by ligature when the teeth are in articulation. The tooth in the line of fracture should not be included in the wiring.

Union takes place rapidly in the maxilla, and when displacement is present the fragments can usually be moulded into position during the first four days. Silk ligatures tied round the necks of the teeth, with the loose ends twisted into a cord, form an effective means for pulling displaced fragments into position. When the fracture is reduced, the maxilla should be fixed to the mandible with a cap splint or by interdental wiring.

In the mandible the fracture should be reduced and immobilized by cap splints or interdental wiring. The tooth in the line of fracture should be extracted, except when the removal of a tooth in the posterior fragment would produce more deformity and render control more difficult in the initial stage of treatment.

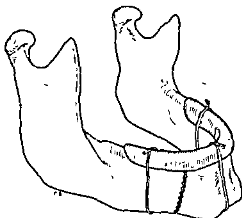


FIG. 101. Circumferential Wiring of Edentulous Mandible.

Edentulous Mandible. Wiring.—When the fracture is simple and the posterior fragment difficult to control, a short incision should be made along the lower border of the mandible, and the bone exposed at the site of fracture. Two holes are drilled in each fragment and the ends drawn together with silver or stainless steel wire.

Circumferential wiring is the most satisfactory method of controlling fractures of the body (Fig. 101). Two or more wires are used to bind the lower denture to the alveolar ridge. A straight Reverdin needle is introduced vertically at the junction of the buccal sulcus and cheek, and passed close to the bone through the skin opposite the lower border of the mandible. The wire is threaded on to the needle, and withdrawn into the mouth. The procedure is repeated on the lingual aspect of the jaw, care being taken to use the same perforation in the skin. Before tightening the wires in the mouth, any tissue between the wire and lower border of the mandible is divided by 'sawing' with the wire.

Epulis.—This is a clinical term used to denote tumours of the alveolar periosteum, and includes giant-cell tumour arising from the alveolo-dental periosteum and fibro-sarcoma arising from alveolar

dental surgeon is most desirable if the best results are to be attained. The fitting of metal cap splints and the use of precision methods in reducing the fracture and in maintaining the jaws in their correct relationship are procedures which have evolved from facio-maxillary clinics.

Interdental wiring is an effective method of immobilizing a fractured jaw when a full complement of teeth is present. Fine brass wire of

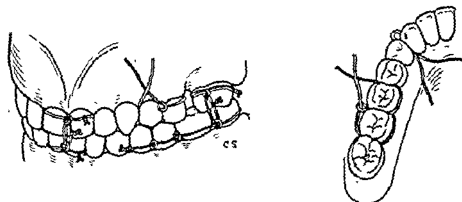


Fig 99 Interdental Wiring of Jaws.

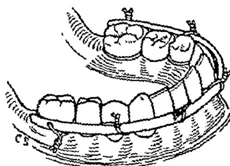


Fig 100 Dental Splint

gauge 0·020 inch is used For ease of manipulation this should be cut into 20-cm. (8-in) lengths, and then stretched between two strong artery forceps. A loop is prepared in the centre of the length by making two twists round the shank of a fine drill (Fig 99). The ends are introduced through an interdental space, separated to encircle the tooth on each side, threaded through the loop, and pulled tight round the necks of the teeth The ends are then twisted, the first turn is the important one, and must be firmly made The wires should be placed round the molars, pre-molars, and incisors in each jaw. The teeth are then brought into articulation, and the upper and lower loops connected with wires or ligatures Elastic traction

the division of the muscles and nerves interferes with swallowing and adds to the risk of aspiration pneumonia. The extent of bone to be removed having been defined, the soft parts are dissected off its anterior aspect, and by means of a Gigli saw the division is effected first on one side and then on the other. If the loose piece of bone is then pulled upon, the diseased area in the mouth can be defined, and with scissors the mucous membrane is divided and the muscles separated from the inner aspect. Haemorrhage is then arrested; sometimes it is necessary to plug the mandibular canal with bone wax. The mucous membrane is sutured as far as possible, and to prevent the tongue falling back and interfering with respiration, it should be transfixed with a silkworm gut suture and held forward. After the wound has healed a denture is fitted, and the prominence of the chin and the alinement of the teeth are thus preserved.

Removal of One-half of the Mandible.—The incision should be planned so as to give access to the glands in the submandibular triangle, which usually require removal at the same time. It passes through the median line of the lower lip down to the hyoid bone; upwards and backwards along the mandibulo-cervical fold to a point 1·5 cm. (½ in.) behind and below the angle of the jaw, and thence curves upwards to the apex of the mastoid. If the red edge of the lip can be left intact, the cosmetic result is better, but this consideration should be disregarded if access must be free. The flap is dissected up, the facial artery and facial vein being secured before they are cut, and the lymph glands are removed. To enable the muscles attached to the jaw to be put upon the stretch, the bone is now divided by a Gigli saw a little to one side of the median line, the central incisor on the affected side being first extracted if necessary. The reflection of the mucous membrane to the gum is next divided with scissors, and then the muscles—genio-hyoid, genio-glossus, digastric, mylohyoid, and medial pterygoid—are detached from the inner aspect of the bone.

If the mandible is now pulled well downwards, the coronoid process can be brought into view and its tip snipped off with bone forceps, or the temporal muscle separated from it. The lateral pterygoid tendon attached to the condyle and the capsule of the joint can be detached by twisting the bone. This avoids the risk of injuring the maxillary artery with cutting instruments, as it lies between the neck of the condyle and the sphenomandibular ligament.

The inferior dental artery is secured at the upper and posterior angle of the wound The stumps of the muscles connecting the tongue to the mandible should be stitched forward before the flap is replaced and sutured Special care is taken to suture the red margin of the lower lip accurately.

periosteum. If not completely removed, these tumours recur locally. An incision is made through the muco-periosteum, wide of the growth, and a wedge-shaped or quadrilateral piece of jaw, including teeth and tumour, is removed by chisel and bone-cutting forceps. If the growth arises from the alveolar process of the maxilla and invades the palate, a V-shaped incision is carried through the muco-periosteum of the hard palate, and the corresponding portion of the palatal bone is removed with the alveolus.

Cysts.—The following types of cyst are not uncommon and may require to be dealt with surgically: (*a*) dental cyst, associated with a dead tooth or root; (*b*) dentigerous cyst, with an impacted or unerupted tooth, (*c*) multi-locular cyst, and (*d*) incisive canal cyst.

Cysts of all types should if possible be dealt with intra-orally. An incision is made along the outer wall, curved at the ends to allow a flap to be turned upwards in the maxilla and downwards in the mandible The flap of muco-periosteum is dissected back and the outer bony wall removed with scissors or chisel. After the contents are removed, the cyst lining should be completely removed and the cavity packed with vaseline gauze to allow healing by granulation. Four days should elapse before the cavity is re-dressed.

In the upper jaw the cyst wall is usually easily detached from the lining of the maxillary sinus, if this is opened, a complete Caldwell-Luc operation (p 229) should be performed to establish nasal drainage, and the flap sutured in the mouth

Cysts arising from the incisive canal are exposed by a curved incision behind the central incisor teeth. A flap is turned back, and the overlying bone removed by chisel and nibbling forceps. The epithelial lining frequently extends well up into the nose, and if difficulty is experienced in dissecting it out completely, the remnants should be curetted with a small sharp spoon. The palatal flap is then resutured. The incisor teeth should not be removed if they give a positive response to a hot instrument applied to the enamel of the crown.

Resection of the Mandible.—Intubation anaesthesia is employed and the pharynx packed off with gauze. The operation varies with the portion to be removed Care must be taken to avoid injuring the supra-mandibular branches of the facial nerve. When possible, the integrity of the mandibular arch should be maintained by conserving the lower border of the bone, but when this is impracticable, a cap splint is applied and a bone graft inserted at a later date

Removal of the Symphysis and Body.—This can often be done through a median incision, splitting the lip and soft parts down to the level of the hyoid bone If this does not give sufficient room, a lateral incision may be added, but this should be avoided if possible as

CHAPTER XIV

OPERATIONS ON THE CRANIAL AIR SINUSES

Maxillary Sinus. Ethmoidal and Frontal Sinuses. Mastoid Sinus. Complications of Middle-ear Disease

OPERATIONS ON THE CRANIAL AIR SINUSES

Maxillary Sinus.—*Proof Puncture and Antral Lavage.*—A Lichtwitz trocar and cannula is used for this procedure. The inferior meatus is first cocainized by packing with 10 per cent. cocaine solution and adrenaline 1 in 1,000 in equal parts, or by the insertion on probes of cotton pledgets soaked in cocaine solution. These should be left in place for fifteen to twenty minutes. The trocar is inserted about 1·5 cm. (½ in.) behind the anterior end of the inferior turbinate and directed upwards and outwards until the antrum is entered. The trocar is withdrawn and an inner cannula attached to a record syringe inserted. A sample of the sinus contents is withdrawn for examination. If desired, the antrum can then be irrigated with a Higginson's syringe. This procedure may be repeated three or four times at short intervals as is necessary.

In acute antral infection advantage can be taken of the proof puncture to introduce into the sinus a fine gum elastic catheter through which 1 c.c. of penicillin solution (10,000 units in 1 c.c.) is injected every three hours. This may obviate the necessity for frequent puncture. In chronic sinus infection penicillin is of little value.

Intranasal Operation.—This is indicated when antral lavage does not control an acute infection or when better drainage and aeration over a short period are desired. The nasal cavity on the affected side is packed with ribbon gauze wrung out of a 10 per cent. cocaine solution containing adrenaline, which is left in position for half an hour. The operation can be carried out without further anaesthesia, but in acute infections some other anaesthetic such as intravenous [illegible]

[illegible] opening is enlarged with the rasp and punch forceps. If the inferior turbinate does not permit access to the antral wall, it may be detached by a cut along it [illegible]

[illegible] In cases of chronic suppuration, and when inspection of the antral cavity is desired. Anaesthesia may be local or general, but in addition the nose should be packed on the side affected with cocaine and

Removal of the Ramus alone.—This operation is performed through the posterior part of the incision employed for removal of one-half of the mandible (p 227)

The bone is exposed in front of the masseter muscle, and divided by means of a Gigli saw passed through the mucous membrane behind the last molar tooth. The subsequent steps are similar to those for removal of half the mandible.

Fixation of the Temporo-mandibular Joint.—Fixation of mandible which is incomplete, due to scar tissue or adhesions round the joint or in the region of the ascending ramus, may be relieved by division of the cicatricial bands This may be done intra-orally or by external incision After the adhesions have been divided, the jaws must be gradually separated with a screw gag, or a boxwood screw fashioned like a spinning top inserted between the molar teeth. When the fixation is due to articular changes, one or both condyles must be resected.

Resection of a Condyle.—A vertical incision is made through the skin, starting immediately in front of the tragus, extending upwards to the level of the upper border of the ear, and curving forwards for 2·5–4 cm. (1–1½ in) over the temporal process. Care must be taken to avoid division of the branches of the facial nerve, and to preserve the superficial temporal vessels. After the skin has been reflected, the superficial fascia containing the superficial temporal artery is dissected forward as a separate flap. The posterior part of the masseter muscle is divided at its attachment to the zygomatic arch, and retracted forwards and downwards To expose the joint, the capsule is incised vertically, and the condyle and neck of the mandible are exposed The condyle is levered out of the joint, and, after separating the lateral pterygoid tendon, the neck is divided by a chisel or by bone-cutting forceps.

Where the meniscus has been destroyed as a result of suppuration and bony ankylosis is present, some care is necessary in chiselling to avoid opening the cranial cavity It may therefore be safer to leave the condyle and restore mobility by excising a considerable portion of the neck. To prevent ankylosis, the fascial flap previously separated should be sutured over the divided neck of the ramus. The operation is completed by suture of the skin flap

D. S. M.

sinus is irrigated and penicillin solution is injected as desired. Ten thousand units every three hours is recommended. General chemotherapy is carried out at the same time. It should be emphasized that although in some cases this is all that will be required, these patients must be kept under the closest observation for some time, because osteomyelitis or frontal lobe abscess may be masked by the apparent well-being produced by chemotherapy.

The Radical Frontal Operation.—This operation is required when chronic sinusitis has failed to clear up under conservative treatment and there is evidence of either acute or chronic disease of bone. In unilateral cases an incision is made in the eyebrow extending downwards on to the nose midway between the bridge and the inner canthus of the eye. The periosteum is retracted and the trochlea elevated with care; the supra-orbital nerve is detached by cutting the canal with a gouge so that the nerve can be held out of the way. The cavity of the sinus is identified through a small opening above the inner canthus of the eye, and with gouge and hammer and rongeur the outer wall and floor of the sinus are removed. Particular care is taken to ensure that the mucous membrane is completely stripped from the medial wall, and that all overhang of the anterior wall is eliminated. The anterior ethmoid cells are then opened from above and all diseased tissue is cleared out. A rubber tube is then passed from the nose into the lowest part of the cavity, and the wound is closed with interrupted sutures. A light gauze bandage is applied over a pad over the sinus cavity, to assist in its obliteration. The chief objection to this operation has been the deformity which results, but recent advances in the plastic repair of facial defects will tend to meet this; there is no doubt that this is the soundest operation from a surgical point of view. In bilateral cases a coronal frontal flap offers the best approach with a minimum of disfigurement.

When a more conservative operation is desired, the skin-graft modification suggested by Howarth is suitable. In this operation the approach is that detailed above, but only the floor of the frontal sinus and enough of the lamina papyracea to give access to the ethmoid are removed. Diseased mucous membrane is removed from the frontal sinus and the ethmoid cells are curetted. Drainage is provided by a tube in the nose. A skin graft cut from th[illegible]
to the soft tis[illegible]
of worsted c[illegible]
the tube. The various packings are brought out through the nostril and are removed about the seventh day. Subsequent treatment consists of irrigation of the sinus through the enlarged intranasal opening and, when necessary, dilatation of the channel

adrenaline solution, which assists haemostasis in the mucous membrane. General anaesthesia is best administered by intratracheal tube with the pharynx packed off to prevent inhalation of blood and pus The cheek is retracted by an assistant, an incision curved downwards is made over the canine fossa in the gingivobuccal mucous membrane, and the muco-periosteum is retracted. The antrum is opened with gouge and hammer, and pus and diseased or polypoid mucous membrane are removed with curette and forceps An opening into the nose is then made through the medial wall of the antrum and a flap of mucous membrane made from the lateral nasal wall is turned down into the antrum. If the anterior end of the inferior turbinate interferes with drainage, it is removed with scissors and snare. The wound in the mouth is closed with catgut sutures.

Frontal Sinus.—*Intranasal Operation.*—This operation is appropriate when it is desired to improve drainage of the frontal sinus by enlarging the fronto-nasal duct The simplest method is, after cocainizing the nose, to remove the anterior end of the middle turbinate with snare and punch forceps. Then the anterior ethmoidal cells are broken into and removed with a curette or with Grünwald's forceps The fronto-nasal duct can then be entered.

External Operations on the Ethmoidal and Frontal Sinuses.—In acute suppuration of these sinuses when conservative treatment has not controlled the infection, it is necessary to open the sinuses from without The guiding principle is to do as little as is consistent with establishing drainage, and evacuating pus. Reliance should then be placed upon chemotherapy to control the general infection, and curative operation can be postponed till the acute stage has passed.

Acute Ethmoidal Suppuration—External operation is required when infection has passed through the lamina papyracea into the orbital space A curved incision is made above the inner canthus of the eye midway between the bridge of the nose and the eye and extending on to the nasal wall Pus is withdrawn and any necrotic bone is curetted out A small tube is stitched into the wound through which penicillin solution is injected at frequent intervals (10,000 units every three hours). The anterior end of the middle turbinate is frequently removed intranasally, and the anterior ethmoidal cells are curetted.

Acute Frontal Sinus Suppuration—A small incision about 2 cm. ($\frac{3}{4}$ in.) in length is made midway between the inner canthus of the eye and the eyebrow The periosteum is exposed and retracted, and with gouge or trephine a small hole is made in the floor of the frontal sinus large enough to admit a fine rubber tube Through this the

then followed up: these may extend forwards into the posterior root of the zygoma, backwards and upwards to the upper knee of the lateral sinus, backwards superficial to the descending portion of the sinus, and down to the tip of the mastoid. In some cases the tip of the mastoid has to be removed, especially when the pus has perforated the inner aspect of the tip and formed a gravitation abscess between the sterno-mastoid and the posterior belly of the digastric muscle. The upper three-quarters of the incision are then united with several silkworm-gut sutures. A drain of gauze or worsted is left in the lower end. The meatus itself should be lightly packed with a strip of gauze or worsted to prevent collapse and to act as a drain for the meatal pus. The dressing is changed on the fifth day, and the drain removed.

Mastoiditis following Chronic Suppurative Otitis Media.—*The Modified Radical Mastoid Operation. Indication*: chronic otitis media with progressive deterioration of hearing. This is the operation of choice in all cases of chronic otitis media in which the hearing is still at a useful level; more radical procedures should be reserved for cases in which obvious destruction of the structures of the middle ear render conservative measures useless or when the presence of complications renders an approach through the middle ear necessary. A curved incision is made 1·5 cm ($\frac{1}{2}$ in.) behind the retro-auricular fold, starting at a point vertically above the centre of the external auditory meatus and continuing to the mastoid process. The incision is carried down to bone in the lower part and to the temporal muscle above. The muscle is retracted upwards and the periosteum is elevated from the mastoid bone.

The bone behind the external bony meatus is then removed with gouge and hammer by successive strokes directed forwards into the external meatus until the level of the mastoid antrum is reached. This is identified by passing a probe through the aditus forwards into the middle ear. The bridge between the antrum and the attic portion of the middle ear is then removed and the middle ear is open for inspection, and diseased ossicles or parts of them can be removed. All granulations, cholesteatomatous tissue, and diseased bone are dealt with, and the cavity is irrigated with warm saline to remove bone chips and other debris

In order to convert the mastoid cells, antrum, aditus, and attic into one cavity which may epithelialize in continuity with the external meatus, it is necessary to cut a plastic flap from the posterior meatal wall. This is done by two incisions: one along the roof of the cartilaginous meatus and one along its floor. The incisions should be carried back into the concha The flap thus outlined is pushed backwards and stitched by means of a mattress suture to the skin just behind the insertion of the auricle. Finally the cavity is packed with

Operations for Complications of Middle-ear Disease

Mastoiditis following Acute Suppurative Otitis Media (Schwartze Operation).—The *indications* for this operation are: (1) pain, mastoid tenderness, and fever continuing in spite of incision of the drumhead (2) Sagging downwards of the meatal wall, oedema or subperiosteal abscess over the mastoid, or gravitation

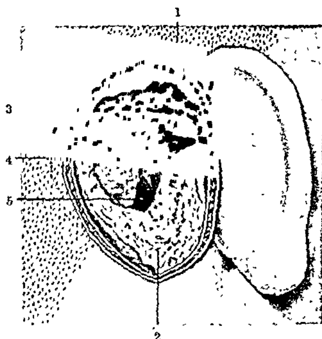


Fig 102 Cavity formed by Operation for Mastoiditis following Acute Middle-ear Suppuration (1) Mastoid antrum (2) Tip of mastoid (3) Upper knee of lateral (sigmoid) blood sinus (4) Sinus plate. (5) Mastoid air cells above digastric fossa.

(*After Dr J S Fraser*)

abscess below the mastoid tip (3) Copious, pulsating, purulent discharge which, after the meatus has been mopped out, rapidly refills the canal (4) Symptoms of an intracranial complication. (5) Persistence of discharge from the ear for more than four weeks.

A curved incision is made down to the bone 1·5 cm (½ in) behind the posterior border of the auricle to a point just below the tip of the mastoid process (*Fig. 102*) The periosteum is separated and a self-retaining retractor inserted The *mastoid cortex is next removed* from behind forwards with gouge and hammer, and the cavity deepened in a medial and forward direction parallel to the posterior bony meatal wall, until the tympanic antrum is reached at a depth of about 1·5 cm. (½ in) from the surface Diseased mastoid cells are

carried out according to the nature of the middle-ear disease. The mastoid bone is now removed with gouge and hammer in a backward direction, in order to expose the upper knee of the lateral sinus. In doing so an extradural peri-sinus abscess is frequently opened and the pus flows out in a pulsating manner. If on inspection the exposed wall of the sinus now shows healthy red or purplish granulations, it is permissible, after free removal of the bony wall of the peri-sinus abscess, to await developments. The wound should be lightly packed and left unstitched. If the temperature comes down and remains normal, nothing further need be done. If, on the other hand, the temperature after twenty-four or forty-eight hours again assumes a hectic character, or if at the original operation the sinus wall appears greyish-brown or sloughy, it is necessary to investigate the condition of the contents. For this purpose the tissues are retracted backwards and if necessary a horizontal incision is made backwards from the middle of the mastoid wound along the superior curved line of the occipital bone. With a gouge and hammer and forceps the bone is removed in a backward direction until healthy bluish sinus wall is reached. Gauze packing is next put in between the sinus wall and its bony groove in order, if possible, to stop the flow of blood from the region of the confluence of sinuses. The sinus is also followed up in a forward direction towards the region of the jugular bulb and gauze packing inserted in this situation. The wall of the sinus is now incised with a tenotomy knife and the clot turned out. As a rule this is accompanied by free bleeding from the sinus itself, in spite of the packing which has been inserted between the sinus and its bony groove. To stop the haemorrhage, packing has to be inserted into the lumen of the sinus.

Opinions vary as to whether the internal jugular vein should be ligated As a rule it is necessary to divide this vessel between ligatures, at the level of the entrance of the common facial, the latter vessel being also divided between ligatures. In the after-treatment saline solution may be syringed through the bulb of the internal jugular vein from the mastoid wound to the upper end of the internal jugular vein in the neck, after removal of the ligature in this latter situation

Intracranial Abscess.—The treatment of intracranial abscess has been influenced greatly by the use of sulphonamides and penicillin, and operation can be delayed until signs of intracranial pressure render interference necessary. Decompression is frequently all that is required until the patient is in fit condition for operation and the abscess has had an opportunity to become encapsulated

Abscess in the Temporal Lobe.—An abscess of the temporal lobe should be drained through the mastoid route when it is caused by

gauze which protrudes from the enlarged meatus. The wound behind the ear is closed with silkworm-gut sutures.

The Radical Mastoid Operation. Indications: (1) chronic otitis media which has caused disorganization of the middle ear; (2) symptoms of labyrinthine or intracranial complications which render complete inspection of the middle ear essential

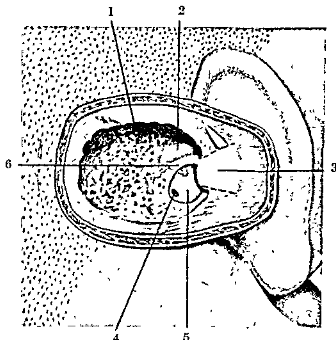


FIG 103 Radical Mastoid Operation completed. (1) Roof of tympanic antrum (cranial plate) (2) Prominence of lateral semicircular canal (3) Koerner flap being cut by knife as outlined by dotted line. (4) Round window niche (5) Promontory (6) Facial canal.

(*After Dr J S Fraser.*)

The procedure is similar to that detailed above, but when the middle ear is exposed, the remains of the drum and the ossicles are removed with forceps or a fine curette, and the middle-ear cavity is carefully cleaned of diseased membrane, granulations, or polypi The Eustachian tube is also curetted. In this part of the operation great care must be taken to avoid the region of the oval window (Fig. 103)

Packing is then inserted and the wound is closed with interrupted silkworm-gut sutures. At the first dressing, which is carried out as a rule on the fifth or sixth day, a skin graft may be inserted.

Septic Thrombosis of the Lateral Sinus following Middle-ear Suppuration.—A retro-auricular incision is made as described under the mastoid operation, and the Schwartze or radical operation

mastoid wound for a distance of about 3·5 cm. (1½ in.) over the cerebellar fossa. The edges are held aside with retractors and the bone removed with gouge and hammer or with a small trephine. The opening thus obtained is enlarged with bone-cutting forceps. The dura is now incised and pus sought for as described above. In some

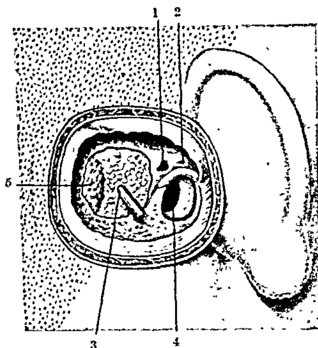


Fig. 104. Operation for Drainage of Cerebellar Abscess. (1) Smooth end of lateral canal followed up into vestibule. (2) Ampullary end of lateral canal. (3) Drainage tube in cerebellar abscess. (4) Opening made into vestibule by joining oval and round windows in cases associated with labyrinth suppuration (5) Lateral (sigmoid) sinus

(After Dr J. S Fraser.)

cases, before efficient drainage is obtained it is necessary to employ both of the routes described.

It occasionally happens that during the operation the respiration ceases, this necessitates artificial respiration and lowering the head of the table to lessen the foraminal impaction of the brain-stem, followed by rapid opening of the posterior fossa and evacuation of the abscess. When this has been done, spontaneous respiration recommences

I. S. H.

direct extension of infection from the tympanic cavity and the surrounding tissues are shut off by adhesions against spread of intracranial infection. The pericranium of the lower part of the squama is separated forwards and backwards. With gouge and hammer or bone forceps the roof of the tympanic cavity and antrum is removed along with the lower part of the squama, thus exposing the dura of the middle cranial fossa. Sometimes in doing this an extradural abscess is opened. Lemaitre's method of draining a temporal lobe abscess consists in making a small opening with a tenotomy knife through the dura in the roof of the middle ear, and inserting Cushing's pus-seeker in a forward and upward direction through the opening. When the stilette is removed the pus is allowed to escape. Thereafter a fine drainage tube is inserted into the abscess cavity and the wound lightly packed with gauze. The tube is removed daily and a fresh one inserted. If the small tube appears to be insufficient, the opening may be slightly enlarged to admit of a tube of larger size. Drainage should be kept up for at least ten days, because if the tube is removed earlier pus reaccumulates and the symptoms of abscess recur.

As a rule the temporal lobe abscess lies close to the roof of the middle ear, but sometimes it lies farther forward or farther back. Accordingly, if the pus is not struck at once it may be necessary to alter the direction when introducing the pus-seeker.

Cerebellar Abscess.—Abscess of the cerebellum, like abscess of the temporal lobe, is usually evacuated along the route by which the infection has passed, i e. through the triangular area of Trautmann which lies medial to the descending portion of the lateral sinus below the superior petrosal blood sinus and behind the descending portion of the facial nerve. Before opening the abscess the radical mastoid operation is carried out After the antrum has been freely opened, bone is removed with gouge and hammer in a backward direction to expose the upper knee and descending portion of the lateral sinus. A protector is now introduced between the dura of the posterior cranial fossa and the posterior surface of the petrous, and the bone is removed in a medial direction with gouge and hammer or with bone forceps Here again an extradural abscess may be found. After a sufficient area of dura has been exposed, the tenotomy knife is inserted and a small opening made sufficient to introduce Cushing's pus-seeker, according to the method of Lemaitre, in a medial and backward direction till pus is evacuated Drainage is carried out by means of a small rubber tube (Fig 104)

An alternative route for draining cerebellar abscess is that through the occipital bone behind and below the lateral sinus. For this purpose an incision is made slanting downwards and backwards from the

Operations for Malformations of the Neck

Operation for Branchial Fistula.—The external orifice of the fistula is situated at the anterior border of the sterno-mastoid muscle immediately above the sternoclavicular joint, or sometimes opposite the thyrohyoid interval, or at the level of the angle of the jaw. The tract follows the anterior border of the sterno-mastoid up to the level of the hyoid bone, piercing the deep fascia about the level of the upper border of the thyroid cartilage; it then passes under the posterior belly of the digastric muscle and between the external and internal carotid arteries to reach the pharyngeal wall If the fistula is complete, the internal opening is usually situated at the intra-tonsillar cleft.

An elliptical incision is made around the external opening, and this is continued upwards along the anterior border of the sterno-mastoid as far as may be necessary. The earlier part of the dissection is comparatively easy, but as the tract recedes from the surface great care is necessary to avoid injury to vessels and nerves. At the level of the lower border of the digastric, the tract is mobilized by blunt dissection as near to the pharyngeal wall as possible. It passes under the hypoglossal nerve and between the external and internal carotid arteries, and approaches the wall of the pharynx between the stylo-hyoid and the stylopharyngeus muscles. If a probe can be passed along the lumen into the mouth, the tract is divided near the upper end The upper part is tied to the probe and turned inside out by pulling the probe out through the mouth. It is then completely removed In cases in which a probe cannot be made to pass along the lumen, the probe is pushed from the wound through the pharyngeal wall and made to appear at the anterior border of the tonsil. An incision is made through the buccal mucosa and the probe drawn into the mouth. The upper part of the fistula is tied to the probe and pulled into the mouth, where it is fixed to the opening in the buccal mucous membrane and the excess cut away. The patient is thus left with a short harmless fistula leading from the upper pole of the tonsil to the anterior border of the tonsil.

Operation for Thyroglossal Cyst and Fistula.—These abnormalities arise in relation to the thyroglossal duct and, since epithelial remnants of the duct frequently extend up as far as the foramen caecum of the tongue, the dissection may be extensive and difficult If possible, a transverse incision 5 cm. (2 in.) long should be employed, but, if the cyst or the external opening of the fistula is below the upper edge of the thyroid cartilage, a midline incision is necessary. The skin and platysma are reflected and the cyst or tract is found lying deep to the sternohyoid muscles. It is freed up to the

CHAPTER XV

OPERATIONS ON THE NECK

Anatomy. Branchial Fistula Thyroglossal Cysts and Fistulae. Cervical Rib.

Anatomy.—In the middle line the following structures may be recognized on palpation· (1) the *hyoid bone*, lying below and behind the body of the lower jaw, on a level with the third cervical vertebra; (2) the *thyrohyoid membrane*, behind which lies the base of the epiglottis and the upper opening of the larynx; (3) the *thyroid cartilage*, to the angle of which the vocal cords are attached about its middle; (4) the *cricothyroid* membrane, across which run transversely the cricothyroid branches of the superior thyroid arteries; (5) the *cricoid cartilage*, one of the most important landmarks in the neck. It lies opposite the disc between the fifth and sixth cervical vertebrae, and at this level the common carotid artery may be compressed against the *carotid tubercle* on the transverse process of the sixth cervical vertebra. The cricoid also marks the junction of the larynx with the trachea, and of the pharynx with the oesophagus, at this point there is a constriction in the food-passage, and foreign bodies are frequently impacted here. At the level of the cricoid cartilage the omohyoid crosses the carotid artery—a point of importance in connexion [illegible] -thetic h [illegible] *ea* lie a [illegible] The *isthmus* of the thyroid gland covers the second, third, and fourth tracheal rings As the trachea passes down the neck, it gradually recedes from the surface, till at the level of the sternum it lies about 4 cm (1½ in) from the skin. The *thyroidea ima* artery—an inconstant branch of the innominate artery or of the aorta—runs in front of the trachea as far up as the thyroid isthmus. The inferior thyroid plexus of veins also lies in front of the trachea.

In children under two years of age the *thymus gland* may extend for some distance into the neck in front of the trachea and carotid vessels, under cover of the depressors of the hyoid bone.

Cervical Fascia —This fascia completely envelops the neck, and from its deep aspect two strong processes—the prevertebral and pretracheal layers—pass transversely across the neck, dividing it into three main compartments. The posterior or *vertebral compartment* contains the muscles of the back of the neck, the vertebral column and its contents, and the prevertebral muscles. This compartment is limited above by the base of the skull, and below is continued into the posterior mediastinum The middle or *visceral compartment* contains the pharynx and oesophagus, the larynx and trachea with the thyroid gland, and the carotid sheath and its contents These different structures derive their special fascial coverings from the processes that bound this compartment. The middle compartment extends to the base of the skull and passes into the superior mediastinum as far as the pericardium. The connective tissue space around the subclavian vessels is continued into the axilla The anterior or *muscular compartment* contains the sternomastoid muscle and the depressor muscles of the hyoid bone. It extends upwards as far as the hyoid bone and the base of the lower jaw, and downwards as far as the sternum and clavicle. The arrangement and limits of the different layers of the cervical fascia explain the course taken by inflammatory products and by new growths in the neck.

along with the external jugular vein, which lies at its posterior border. The deep fascia is divided and the transverse cervical vein is secured as it crosses the posterior triangle to join the external jugular. The posterior belly of the omohyoid is then freed from the deep fascia and drawn upwards. The transverse cervical artery is picked up and divided as it crosses in front of the brachial plexus. The plexus is then identified at the lateral border of the scalenus anterior in front of the scalenus medius. It is mobilized by dividing the overlying prevertebral fascia and is retracted gently downwards and medially. At this stage care must be taken not to injure the upper two roots of the long thoracic nerve as they emerge from the scalenus medius; the nerve lies on a plane posterior to the lateral part of the plexus, and the slender roots may be torn as the plexus is retracted. The cervical rib can usually be felt through the substance of the scalenus medius. This muscle is divided over the proximal part of the rib and stripped completely from it. The rib may then be cleared and divided along with its periosteum immediately beyond the transverse process of the cervical vertebra. The clearing is continued in the forward and downward direction; a layer corresponding to Sibson's fascia is freed from the medial border of the rib, care being taken to avoid injury to the pleura; from its under surface a sheet of muscular fibres representing intercostal muscles is separated. At its anterior end, the cervical rib is usually fixed to the first thoracic rib in the region of the scalene tubercle by fibrous tissue or bone. To expose this connexion, the lowest trunk of the brachial plexus and the subclavian artery must be gently displaced forwards. The anterior connexion is then divided and the rib removed. In the rare cases in which the cervical rib extends forwards beyond the scalene tubercle, it is sufficient to divide the rib at the level of the tubercle, as the anterior part produces no harmful symptoms.

In those rare cases of pressure on the lower part of the brachial plexus by the medial border of the *first thoracic rib*, an operation is performed on similar lines. The first rib is exposed and the portion between the neck of the rib and the scalene tubercle is cleared and removed.

To prevent the formation of a haematoma, haemorrhage should be carefully arrested and firm pressure applied by means of a large pad of wool and a bandage.

Operations for Wry-neck are referred to on p. 138.

W. Q. W.

hyoid bone to which, at this level, it is usually found to be attached. To ensure complete removal, it is best to resect the central 0 5 cm. (¼ in.) of the hyoid bone. From this point to the foramen caecum no further attempt is made to dissect out the tract, but a 'core' of muscular tissue, containing epithelial remnants of the duct, about 0·5 cm. (¼ in) in diameter, is removed. This includes portions of the mylohyoids, genio-hyoids, genioglossi, and of the intrinsic muscles of the tongue. The deeper part of the wound is closed with buried catgut sutures and a small rubber drain brought to the surface.

Cervical Rib.—Cervical rib may be dealt with by division of the scalenus anterior muscle, as recommended by Adson, or by excision of the rib.

Scalenotomy —An oblique incision 5–8 cm. (2–3 in.) in length is carried from the sternoclavicular articulation upwards and backwards into the posterior triangle. The sterno-mastoid is exposed after division of the fascia and platysma and the clavicular head is divided between forceps The clavicular portion is dissected medially, exposing the omohyoid and the scalenus anterior. The phrenic nerve crosses the scalenus anterior obliquely in the downward and medial direction, lying behind the prolongation of the prevertebral layer of fascia The internal jugular vein is retracted medially and the borders of the scalenus anterior freed from the fascia. The phrenic nerve is freed in the upward direction for at least 5 cm. (2 in) and retracted medially The subclavian artery is observed deep to the muscle and the pleura may be seen medially and behind; these two structures must be carefully protected as the muscle is divided. The tendinous attachment of the scalenus anterior is then cut across The artery is mobilized for a short distance and is seen to fall forwards, thus relieving the pressure on the underlying nerve trunk. If there is any doubt about the pressure being completely relieved, a portion of the cervical rib is removed with a rongeur.

Removal of Cervical Rib.—The patient's head is turned to the opposite side, the shoulders slightly elevated, and the arm drawn well down and fixed to the operating table. An angular incision is made, one limb being placed over the lower third of the anterior border of the trapezius and the other being carried medially immediately above the middle third of the clavicle. To facilitate exact apposition afterwards, it is advisable to scratch the line of the incision transversely with a needle at several points. The platysma and the middle supraclavicular nerves are divided as the flap is raised; it may be possible to preserve the posterior supraclavicular nerves, and the accessory nerve must be carefully avoided at the upper end of the incision. The sterno-mastoid is defined at the anterior end of the incision and is mobilized and drawn forwards

loose tissue that constitutes the sheath at the level of the lower pole, and finally passes beneath the lower border of the inferior constrictor to supply all the muscles of the larynx except the cricothyroid muscle. Within the thyroid sheath the recurrent nerve most frequently lies behind the inferior thyroid artery, but it may lie anterior to the vessel or between its branches.

The *parathyroid* glands vary in number and in situation. They are flattened elliptical bodies, averaging a quarter of an inch in length and an eighth of an inch in width, of a light-brown colour, smooth and glistening on the surface, and of a soft, flabby consistence. There are usually two glands on each side,

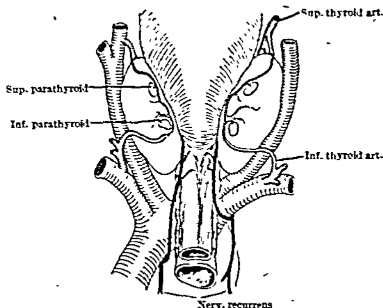


Fig. 105. To illustrate Position, Relations, and Blood-supply of Parathyroid Glands: seen from behind.

which lie within the thyroid sheath on the posterior border of the lobe. The superior parathyroid, derived from the fourth branchial pouch, is situated usually at the level of the junction of the upper and middle thirds of the lobe; the inferior parathyroid, derived from the third branchial pouch, lies nearer the lower pole in relation to the termination of the inferior thyroid artery and a short distance lateral to the recurrent nerve (Fig. 105). Both glands lie as a rule alongside the communicating branch between the superior and inferior thyroid arteries, which is a guide to them. Each gland is supplied by a twig, usually from the communicating branch, or directly from the inferior thyroid. The parathyroid glands may, however, be related to any part of the posterior surface of the lobe, and occasionally may be found on the lateral aspect, or even on the anterior surface. The lower parathyroid occasionally lies behind the thyroid sheath (Walton). The branchial origin of the parathyroids explains the exceptional presence of parathyroid tissue outside the limits of the thyroid gland in the neck, or even in the superior mediastinum in relation to the thymus.

Operations for Goitre

The operative procedure required varies with the type of goitre. Owing to the vascularity of the gland, special care must be taken to

CHAPTER XVI

OPERATIONS ON THE THYROID GLAND

Anatomy. Operations for Goitre. Toxic Goitre. Simple Goitre. Intrathoracic Goitre. Malignant Disease. Parathyroidectomy. Thymectomy.

Anatomy.—The *thyroid* gland lies under cover of the infrahyoid muscles. The lateral lobes lie in relation to the larynx up to the middle of the thyroid cartilage, and to the sides of the first five or six rings of the trachea. The isthmus lies in front of the second, third, and fourth rings of the trachea, and from it, in a considerable proportion of cases, a process of gland-tissue—the pyramidal lobe—passes upwards usually to the left of the middle line.

The thyroid is enclosed by its own capsule, which is continuous with the stroma of the gland, and is surrounded by a sheath of the pretracheal fascia loosely connected to the capsule except where the gland is in contact with the trachea. Through the attachment of its sheath to the trachea and larynx the gland moves with the larynx during swallowing

The four main *arteries* of supply—the superior and inferior thyroids—are large for the size of the gland The superior thyroid artery divides at the upper pole of the gland into branches which are distributed mainly to the anterior and lateral surfaces of the lobe, a small posterior branch usually anastomosing with a branch of the inferior thyroid artery. The inferior thyroid artery reaches the gland at the middle of the lateral border of the lobe and passes downwards and medially to enter the thyroid-sheath close to the postero-medial border. Within the sheath the terminal branches of the artery penetrate the capsule mainly on the postero-medial border of the lobe at the junction of its lower and middle thirds The recurrent laryngeal nerve and the lower parathyroid are in close relation to the artery and its branches within the sheath The thyroidea ima, when present, goes to the isthmus.

A further blood-supply is gained from extra thyroideal branches of the tracheal, laryngeal, and pharyngeal arteries, these vessels play an important part in maintaining the blood-supply of the remaining glandular tissue and of the parathyroids after a partial bilateral resection of the gland, in which both superior thyroid arteries and the main trunks or the terminal branches of both inferior thyroid arteries have been tied

The three main sets of *veins* which leave the thyroid are derived from a network of veins which lies on the capsule of the gland beneath the sheath The superior thyroid vein leaves the upper pole with the corresponding artery and terminates in the internal jugular vein, which receives also the middle thyroid vein from the lateral aspect of the gland The inferior thyroid veins terminate in the innominate veins within the thorax. The main *lymphatics* leave the capsule of the gland with the veins, and are distributed to the deep cervical, tracheal, and mediastinal glands. Occasionally a lymphatic trunk opens into one of the large veins at the root of the neck

The *nerve-supply* is derived from the sympathetic and from the laryngeal branches of the vagus, and the nerves accompany the thyroid arteries. The external laryngeal nerve, which supplies the cricothyroid muscle, passes downwards on the inferior constrictor of the pharynx, where it covers the thyroid cartilage, deep to the superior thyroid artery and to the medial surface of the upper pole of the gland The recurrent laryngeal nerve on each side ascends in the groove between the oesophagus and trachea, penetrates the

loose tissue that constitutes the sheath at the level of the lower pole, and finally passes beneath the lower border of the inferior constrictor to supply all the muscles of the larynx except the cricothyroid muscle. Within the thyroid sheath the recurrent nerve most frequently lies behind the inferior thyroid artery, but it may be anterior to the vessel or between its branches

The *parathyroid* glands vary in number and in situation They are flattened elliptical bodies, averaging a quarter of an inch in length and an eighth of an inch in width, of a light-brown colour, smooth and glistening on the surface, and of a soft, flabby consistence. There are usually two glands on each side,

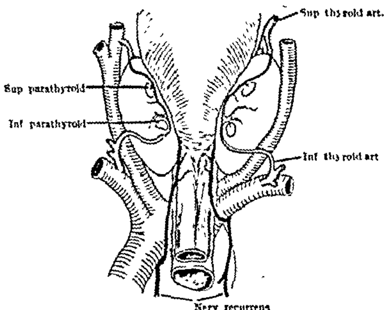


FIG. 105. To illustrate Position, Relations, and Blood-supply of Parathyroid Glands: seen from behind.

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OPERATIONS FOR GOITRE

The operative procedure required varies with ... f goitre. Owing to the vascularity of the gland, special care ... be taken to

control haemorrhage during the operation, and to ensure satisfactory haemostasis. The difficulties of the operation are increased in cases in which the trachea is displaced or compressed, and when the goitre is retrosternal or intrathoracic. It is important to plan the operation in such a way that damage to the recurrent and external laryngeal nerves is avoided, and that the parathyroids are preserved with their blood-supply intact. Recurrent nerve paralysis may result from division of the nerve, or from its inclusion in a ligature, or by pinching it with forceps. Paresis of the nerve may be due to stretching or to trauma from rough handling, particularly when the finger is introduced behind the lobe in attempting to elevate or mobilize it. The nerve is more exposed to damage behind the middle third of the lobe and where it passes beneath the cricopharyngeus muscle than at the lower pole. Except in the case of isolated adenomas, which can be shelled out, it is usual to perform partial resection of one or both lobes. Complete resection of a lobe is rarely advisable owing to the risk of removal of the parathyroid glands. When both lobes are enlarged a bilateral resection is performed in order that the reduction in size of the goitre will be symmetrical, and to ensure a satisfactory aesthetic result. The amount of thyroid tissue to be left varies with the functional activity of the gland

Anaesthesia.—Endotracheal anaesthesia with gas or cyclopropane and oxygen is the method of choice. Omnopon gr. $\frac{1}{3}$ and hyoscine gr. $\frac{1}{150}$ should be given two hours before the operation, and if necessary a second dose of omnopon gr. $\frac{1}{6}$ and hyoscine gr. $\frac{1}{200}$ may be given one hour later In cases of toxic goitre, and in simple goitre when the trachea is narrowed or displaced, tracheal intubation to ensure a free airway is essential for the safety of the patient.

Local analgesia can be employed in almost any type of goitre, but with the modern methods of general anaesthesia it is seldom to be preferred However, it may be the safest method when compression of the trachea is associated with bronchial catarrh and increased secretion, and in the more serious cases of auricular fibrillation with cardiac decompensation A solution of $\frac{1}{2}$ per cent novocain is employed with adrenaline in the proportion of 1 in 200,000 A total amount of 200 c c should not be exceeded The anaesthesia may be induced by local infiltration of the operation area or by a regional block of the cervical nerves It is advantageous to combine the two methods, and to commence by the injection of 10–20 c.c. of the novocain solution at the middle of the posterior border of each sterno-mastoid muscle The anaesthetic should then be injected subcutaneously along the line of the skin incision and thereafter over the area corresponding to the skin flaps and beneath the preglandular

muscles. It is essential to introduce the fluid around the upper poles and above the isthmus of the gland. If necessary the local anaesthesia can be supplemented with gas and oxygen.

Operations for Toxic Goitre

Operation should be recommended in cases of primary toxic goitre which fail to make satisfactory progress after adequate medical treatment. Prior to the introduction of thiouracil, operation was regarded as the routine treatment for all cases of primary toxic goitre, after a preliminary course of iodine Although there has not yet been sufficient time to show the proportion of cases which can be kept in a state of normal health by a maintenance dose of thiouracil, or can be ultimately cured, there is ample evidence to show that thiouracil is the most effective medical agent yet available, and the indications for operation must be more precisely defined than was formerly necessary.

After a three weeks' course of 0·6 gm. daily of thiouracil the symptoms of toxicity are usually in abeyance, and the patient has already regained much of the weight previously lost With a maintenance dose of 0 05 to 0·1 gm. daily the improvement continues, and in many cases the patient is able to resume work There is little or no reduction in the size of the gland, which becomes softer and more vascular as the colloid content is reduced. If the maintenance dose has been excessive the gland will become even larger than before, and pressure symptoms and signs of myxoedema may appear. The patient is occasionally resistant to the drug, and in other cases signs of acute sensitivity or of toxicity may develop, or certain symptoms may persist.

Operation is clearly indicated in cases treated by thiouracil if the patient is resistant, if signs of acute sensitivity appear, if there is a pronounced leukopenia or other evidence of toxic action, and in cases in which there is incomplete relief of toxic symptoms, of which tachycardia is the most common symptom to persist. Operation should also be advised if the gland remains unduly large, or is causing pressure symptoms

It is well known that the improvement in the symptoms coincides with a reduction of the amount of the colloid which contains the hormone within the glandular acini. This explains the delay in the action of thiouracil in normal glands and in the large nodular goitres associated with secondary toxic symptoms While thiouracil may be as effective in secondary as in primary toxic cases, operation should be more often recommended in the former, particularly when the nodular enlargement is marked, and always in cases with a retrosternal extension of the goitre. While thiouracil, alone or with a

subsequent course of quinidine, may be effective in restoring normal rhythm in cases of auricular fibrillation, there is no doubt that further improvement can be achieved by operation in some cardiac cases in which the relief has been only partial. There are cases also in which operation is advisable owing to the lack of co-operation on the part of the patient by failure to continue the medical treatment, or owing to difficulty in arranging for the regular medical supervision that is essential, as in the case of a patient who is going abroad.

Pre-operative Treatment.—As an alternative to iodine, thiouracil has the advantage that its effect is maintained and continuous, and there is no restricted optimum period when the maximum benefit is reached, as in the case of the former drug. In most cases the vascularity of the gland is definitely increased after a course of thiouracil, and it has been shown by experience in the case of the patient prepared with thiouracil that the gland is firmer and the bleeding less if the patient is also given a course of iodine for ten days before operation

Preparation with iodine is indicated in those cases which have failed to respond satisfactorily to thiouracil, or in which the drug has had to be withheld on account of toxic reaction. Iodine is given in the form of Lugol's solution (5 per cent. iodine and 10 per cent. aqueous potassium iodide), of which 5–10 minims is the daily dose, but if the symptoms are severe 50–100 minims should be given daily by mouth, or by rectum if the patient is unable to take fluids on account of vomiting If rectal administration is impossible owing to diarrhoea, 20 minims of Lugol's solution may be administered intravenously with 5 per cent. glucose-saline every six hours. The operation should be performed when the maximum benefit is apparently reached, which is usually within a period of ten days to three weeks

Ligation of the Superior Thyroid Artery.—Ligation of the superior thyroid arteries, as a separate operation, is performed only in cases of toxic goitre, when surgical treatment is indicated but the patient's condition is too serious to justify the risk of thyroidectomy. In such rare cases the operation of thyroidectomy is usually performed later in one or two stages. Both arteries may be ligated at the same operation, or it may be necessary to allow an interval of a few days between the two ligations The vessel is exposed, under local anaesthesia, where it lies beneath the depressor muscles at the upper pole of the gland. When the artery is enlarged its pulsation can sometimes be felt, and a short transverse incision is made directly over the vessel in the line of, or parallel to, one of the normal skin folds. If the vessel is not obvious the incision is made over the upper pole of the thyroid lobe After the platysma has been divided the deep

cervical fascia is incised in a vertical direction, and the depressor muscles are separated in the same line. By retraction of the separated muscle fibres to either side the superior thyroid artery, with its accompanying vein, is exposed. It is ligated immediately above the point at which it divides into its branches at the upper limit of the pole.

Bilateral Partial Thyroidectomy for Primary Toxic Goitre.—It is necessary for the safety of the patient to complete the operation without waste of time. A plan of procedure and good assistance are therefore essential. The dissection must be carried out with

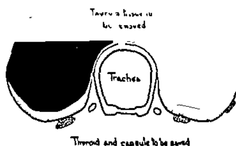


FIG. 106. D[illegible]

precision and gentleness; rough and hurried operating will only add to the haemorrhage. As far as possible forceps are not applied to the gland, because in vascular goitres they may tear the gland and thereby increase the amount of bleeding The lobes are retracted by finger pressure over gauze, this serving also to control bleeding-points on the surface of the gland. Small bleeding-points exposed after the reflection of the flaps are coagulated with the diathermy current, but all other vessels divided in the operation are ligated with catgut.

The shoulders are elevated and the neck is extended over a pillow so that the front of the neck is exposed to its fullest extent, and the chin points upwards without deflection to either side. In vascular goitres and when the superficial veins are distended the table may be tilted so that the patient lies on a slight incline with the head elevated

The collar incision of Kocher affords free access and leaves an almost imperceptible scar It extends from the lateral border of one sterno-mastoid to the lateral border of the other, and should be made in, or exactly parallel to, one of the skin creases In order to avoid

an obliquity of the incision it is advantageous to measure the distance of the ends of the proposed incision above the clavicles and to mark these points with a probe dipped in dye. It is helpful also to outline the exact line of the incision by marking the skin with a silkworm gut suture stretched tightly between forceps. If the goitre is of moderate size the incision is made 2·5 cm. (1 in.) above the



Fig 107. The Line of Incision.

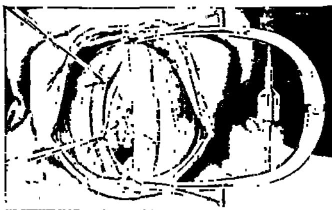


Fig 108 Retraction of Flaps

suprasternal notch, but in larger goitres the incision should be placed at a slightly higher level The platysma may be divided at the same level, but, if well developed, it is better to reflect the skin and subcutaneous tissues for a short distance and to divide the platysma at a higher level so that the sutures uniting its edges may not lie immediately beneath the line of the skin incision (Figs 106–12.)

The upper flap of skin and platysma is reflected by sharp dissection from the deep cervical fascia covering the pretracheal muscles to above the level of the thyroid cartilage, while the central part of the lower flap is freed downwards to the suprasternal notch The subsequent steps of the operation are facilitated if the flaps are widely

separated by a Joll's self-retaining retractor. The anterior jugular veins can usually be preserved, and only communicating branches require ligation; but if the depressor muscles are to be cut across, or if the veins have been wounded, they should be doubly ligated, divided, and dissected upwards and downwards with the flaps.

A vertical incision is now made through the deep cervical fascia, and the depressor muscles are separated in the midline. The sterno-hyoid and sternothyroid muscles, with the thyroid sheath, are raised



FIG. 109. Ligation and Division of Middle Thyroid Vein.

from the corresponding lobes, usually first on the right side, special care being taken to separate completely the fibres of the sterno-thyroid muscle where it is closely applied to the upper pole. In most cases the retraction of the depressor muscles, after they have been freely separated in the midline, is sufficient, but if the exposure is inadequate, the sternohyoid and sterno-thyroid on one or both sides should be divided transversely near their upper attachments. In this way their nerve-supply is preserved intact, and better access is obtained to the upper pole and superior thyroid artery; and when the muscles are stitched the line of suture lies at a different level from that of the skin incision, and the scar is less likely to be adherent. In old-standing cases of toxic goitre, when the gland is extremely friable, the control of bleeding is often difficult, and the fullest exposure is advisable.

Mobilization of the upper pole is facilitated if at this stage the lateral border of the lobe is freely exposed and the middle thyroid

vein is divided between ligatures. The upper pole of the right lobe is then exposed by retraction of the sternohyoid and sterno-thyroid muscles in an upward and lateral direction, and any further traces of the thyroid sheath are stripped from the capsule covering its upper limit. After the pole has been gently pulled forwards, a catgut ligature is drawn through by means of a pair of curved artery forceps passed behind the pole from the medial to the lateral side, and tied around the superior thyroid vessels. To avoid the risk of the ligature

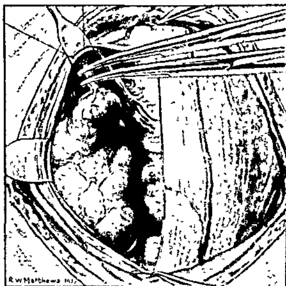


FIG. 110 Ligation and Division of Superior Thyroid Vessels.

slipping, two pairs of forceps are applied above the apex of the pole, the vessels are divided between the forceps, and again ligated.

After the superior pole has been dealt with, the retractors are re-adjusted in order to expose the lateral aspect of the lobe. By drawing the lobe forwards the inferior thyroid artery can be exposed and ligated at the point where it emerges from behind the carotid sheath to pass downwards and medially. This step is of advantage in specially vascular goitres Care must be taken to apply the ligature well away from the gland in order to avoid any risk of damage to the recurrent nerve, and this can be facilitated by retraction of the carotid sheath laterally Finally the lower pole is cleared of its sheath, and the inferior thyroid veins are ligated and divided The other lobe is then mobilized and the vessels are ligated in the same order From these steps it follows that the whole of the gland is exposed and mobilized before the resection of the lobes is commenced.

The upper and lower borders of the isthmus are next defined, and if a pyramidal lobe is present it is freed at this stage. The isthmus is divided between clamps in the midline. By sharp dissection the right half of the isthmus and the corresponding lobe are freed from their attachment to the front and anterior half of the lateral aspect of the trachea. At this stage in the dissection the lobe is entirely separate from the surrounding tissues, except on its posterior and postero-medial aspects, and can be lifted forwards. As the resection

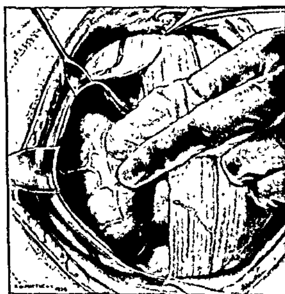


FIG. 111 Ligation in Continuity of Superior Thyroid Artery.

is completed from the medial to the lateral side, there is left a layer of thyroid tissue which should vary in thickness according to the functional activity of the gland. The area to be retained should include the posterior and lateral parts of the capsule with a layer of thyroid tissue extending from immediately below the extremity of the superior pole to a level close to the limit of the lower pole below; and from the lateral border of the lobe to the margin of the medial surface, where it lies midway between the anterior and posterior surfaces of the trachea In toxic cases a thin layer of thyroid tissue approximating to about one-third of a normal lobe is left on each side By retaining the lateral as well as the posterior part of the capsule there is less risk of removing one or more parathyroids, which may lie more laterally than usual. Vessels which are obvious in the capsule, including the terminal branches of the inferior thyroid artery, are clamped before they are divided, but numerous smaller vessels must be secured as the division of the lobe proceeds.

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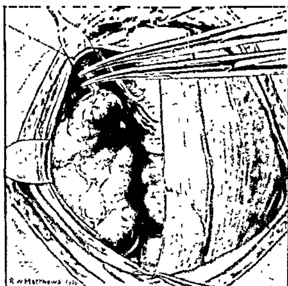


FIG. 110. Ligation and Division of Superior Thyroid Vessels

slipping, two pairs of forceps are applied above the apex of the pole, the vessels are divided between the forceps, and again ligated.

After the superior pole has been dealt with, the retractors are re-adjusted in order to expose the lateral aspect of the lobe. By drawing the lobe forwards the inferior thyroid artery can be exposed and ligated at the point where it emerges from behind the carotid sheath to pass downwards and medially This step is of advantage in specially vascular goitres Care must be taken to apply the ligature well away from the gland in order to avoid any risk of damage to the recurrent nerve, and this can be facilitated by retraction of the carotid sheath laterally Finally the lower pole is cleared of its sheath, and the inferior thyroid veins are ligated and divided. The other lobe is then mobilized and the vessels are ligated in the same order. From these steps it follows that the whole of the gland is exposed and mobilized before the resection of the lobes is commenced.

Operations for Simple Goitre

Operation is indicated in simple goitres which are steadily increasing in size, and when there are symptoms of pressure on the trachea or other structures. Conditions such as foetal adenoma, cysts, and large adenomatous nodules are not amenable to medical treatment. Operation is justifiable for aesthetic reasons in large or nodular goitres, and should be recommended if there is any suspicion of malignancy.

It is advisable to operate in retrosternal or intrathoracic goitres, as the ultimate prognosis is grave if the condition is left untreated.

Enucleation of Adenoma or Cyst of the Thyroid.—In this operation the tumour is shelled out from its bed of thyroid tissue so that there is no exposure of the main arteries, recurrent nerve, or parathyroids.

The collar *incision* is made over the most prominent portion of the gland. Access is obtained by separating the pretracheal muscles in the median line; it is seldom necessary to divide the muscles. The thyroid sheath is reflected from the surface of the affected lobe, and the rest of the gland is inspected. The capsule and investing thyroid tissue are divided until the tumour is exposed; it is then enucleated by blunt dissection, all vessels being secured as they are divided. The cavity left is closed by interrupted sutures. No drain is required as a rule, and the operation is completed as in other forms of goitre. Several small tumours can be dealt with in this way, but, when more than one are present, or if the adenoma is relatively large and the surrounding thyroid tissue is much compressed or reduced, it is advisable to tie the superior thyroid vessels and to remove the affected lobe with the exception of the posterior part of the capsule and thyroid tissue in relation to the parathyroids and recurrent nerve.

Bilateral Partial Resection of Diffuse Colloid Goitre.—Operation is performed only for relief of pressure symptoms or for deformity which has persisted in spite of medical treatment The vascularity is relatively less than in typical cases of primary toxic goitre, but in most colloid goitres of average size the main vessels are enlarged and the veins on the capsule are dilated. The gland may be very vascular in young patients with a parenchymatous type of goitre without much colloid formation. Most large goitres can be readily mobilized, but the operation is rendered difficult when the trachea [illegible]

ties of the operation.

The left lobe is then resected in a similar way, and after all bleeding-points have been tied the medial and lateral edges of the remnants of thyroid tissue are united by interrupted catgut sutures. If approximation is difficult owing to the rigidity or friability of the thyroid tissue, no attempt should be made to suture the edges; experience has shown that there is apparently no tendency to



FIG 112 Resection of Right Lobe.

increased absorption of thyroid secretion if the raw surfaces are left exposed

Before the wound is closed, provision is made for drainage even when haemostasis appears to have been complete. A fine rubber drain is inserted on each side through a small puncture in the pretracheal muscles at the anterior border of the sterno-mastoid The pretracheal muscles and the platysma are united separately with interrupted catgut sutures The skin edges are brought together with Michel clips The drains are removed in twenty-four hours, and if after their removal minute gaps remain in the skin incision an additional Michel clip is applied on each side All the skin clips are removed on the third day after operation, and collodion is applied across the line of the skin incision to prevent stretching of the scar during the early stages of repair

Operations for Intrathoracic Goitre

The extension of a nodular goitre behind the sternum is not uncommon, but it does not as a rule increase materially the difficulty of the operation. When the goitre is mainly or wholly intrathoracic it is usually formed by an encapsulated adenoma continuous with or attached by a pedicle to the lower pole of one or other lobe, and in such cases the operation is likely to be difficult.

Although an intrathoracic goitre occasionally implicates both sides of the trachea within the chest, the growth is usually connected with only one lobe of the thyroid.

The blood-supply is derived from the thyroid arteries in the neck, and haemorrhage can therefore be controlled by preliminary ligation of the vessels supplying the corresponding lobe. An intrathoracic goitre is surrounded by a sheath derived from the pretracheal layer of cervical fascia, from which it can readily be separated without much risk of damage to the surrounding structures in the mediastinum, unless adhesions have formed.

Before operation is undertaken, radioscopic examination is necessary to determine the size and position of the goitre and its relation to the trachea. The position of the trachea, which is usually narrowed and displaced to one side, will indicate the lobe to which the intrathoracic goitre is attached. It is essential also to examine the thorax under the screen and to note if the shadow of the tumour moves upwards on swallowing. Absence of mobility is exceptional and suggests fixation of the growth by adhesions or by a malignant change, which will render removal of the tumour specially difficult or impossible.

A collar *incision* is made low down in the neck and the thyroid gland is freely exposed by transverse division of the depressor muscles, occasionally it may be necessary to detach the sternal head of one or other sterno-mastoid to obtain more room. The thyroid is examined to determine the lobe with which the retrosternal growth is connected, and the position of the trachea is identified.

The first step in the removal of the goitre is to tie and divide the superior thyroid vessels and to free the upper pole of the lobe to which the retrosternal growth is related. The middle thyroid vein is secured and divided, and the lateral aspect of the lobe is freed. The inferior thyroid artery is now tied in continuity. The isthmus of the thyroid is then divided and the lobe is freed from its attachment to the trachea. The lobe is now resected from above downwards, leaving only the posterior part of the capsule intact but maintaining continuity between the lower pole and the intrathoracic tumour, which may be connected by a fibrous pedicle. The inferior

In large goitres the collar incision should be placed at a correspondingly higher level in order to prevent the scar sinking downwards, and should be of adequate length to give free exposure. If sufficient room is not obtained by retraction of the pretracheal muscles, they should be divided transversely. The subsequent steps of this operation may require to be modified if the trachea is much compressed or if the gland is unusually vascular.

In most cases the technique described for toxic goitre (p. 245) may be followed with advantage, haemostasis being controlled by preliminary ligation of the superior thyroid arteries, and by ligation of the terminal branches of the inferior thyroid arteries during the resection of the lobes.

Any attempt to displace forwards a retrotracheal extension of the goitre should be postponed until the middle and inferior thyroid veins have been tied and the lateral border of the lobe and the lower pole have been freed. When these steps have been completed the lobe can be drawn forwards with less risk of damaging the recurrent nerve than if earlier forcible attempts are made to dislocate the lobe with a finger placed behind it. In specially vascular types of goitre both superior as well as both inferior thyroid arteries may be ligated, and, provided the posterior attachments of the capsule have not been separated, the collateral circulation can be relied on to maintain an adequate blood-supply to the remaining thyroid tissue and to the parathyroids Owing to the lessened functional activity of the gland it is necessary in colloid goitres to leave on each side an amount of gland substance greater in size than a normal lobe.

Enucleation-resection of a Nodular Goitre.—When numerous adenomatous masses are scattered through the gland, enucleation alone is not a practicable method, and partial resection of one or both lobes—if the goitre is bilateral—should be performed, combined, if necessary, with enucleation of individual nodules. If the nodules are small and are distributed uniformly throughout the gland, enucleation is impossible and a resection of both lobes is performed as in colloid goitre. More frequently the nodules are of varying size and occupy the greater part of one or both lobes, while the rest of the thyroid tissue is normal or has the characteristics of a colloid goitre. The thyroid tissue in relation to the posterior part of the capsule is usually least altered The steps of the operation and the control of haemorrhage are the same as for partial thyroidectomy. As far as possible a resection is performed with enucleation of the adenomatous nodules when a satisfactory line of cleavage can be found.

When the trachea is displaced it is important to determine its position by radioscopic examination before the operation, and to deal first with the lobe responsible for the displacement.

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thyroid veins are not seen at this stage as they are usually at a lower level within the thorax. If the lobe is considerably enlarged and is continuous with the intrathoracic goitre, resection is postponed till the retrosternal portion has been brought to the surface; the partial mobilization of the lobe is sufficient to facilitate the elevation of the retrosternal portion, and, if the inferior thyroid artery has been ligated, serious haemorrhage is prevented.

The intrathoracic tumour is made more accessible by traction on the thyroid lobe in an upward direction. When the upper limit of the intrathoracic goitre has been brought into view by traction on the thyroid lobe, the fibrous sheath surrounding it is separated with a dissector or the finger; on further traction from above, the growth can usually be delivered without much difficulty into the neck, and the inferior thyroid veins can then be secured.

Difficulty is met with if the adenomatous mass is larger than the thoracic inlet, and it is sometimes necessary to pass the finger or a spoon-shaped elevator underneath the growth to lever it up. It is always safer to pass the finger or the spoon downwards behind an intrathoracic goitre, as the proper line of cleavage is more easily found posteriorly, and in this situation there are no veins liable to be torn. When elevation of the growth is difficult on account of its size, the delivery of the tumour is facilitated if pressure from below is combined with traction from above (Lahey). If an adenoma within the thorax is cystic and too large to be elevated it should be punctured before the cyst wall is pulled upwards. It is rarely necessary to break up the growth and to remove it piecemeal.

In exceptional cases, when an intrathoracic goitre is fixed by adhesions and the proper line of cleavage within its fascial sheath is obliterated, removal is possible only after division of the sternum.

After the intrathoracic goitre has been elevated, the cavity within the mediastinum is temporarily packed with gauze, while the removal of the goitre together with the corresponding lobe is completed and all vessels are tied. The pack is then removed and bleeding points in the cavity are sought for and secured. When the cavity is dry, the wound is closed in the usual way with provision for drainage.

Operations for Malignant Disease of the Thyroid

Malignant disease of the thyroid is treated by operation followed by a course of radiotherapy, or by irradiation alone. The rapidly growing and usually inoperable forms of spheroidal-cell carcinoma are more radio-sensitive than the differentiated tumours such as malignant adenoma or papillary adenocarcinoma. The view formerly held that the spheroidal-cell tumours were radio-resistant was due,

probably, to the advanced stage of the disease and to inadequate irradiation (McWhirter).

Indications.—Operation should be undertaken when there is a suspicion of malignancy, and the diagnosis from chronic thyroiditis or a simple form of goitre is impossible without exploration. There is a good prospect of recovery if a malignant adenoma or papillary type of tumour is removed while it is still intracapsular. While the growth is intracapsular the regional lymph glands are seldom involved, but the presence of enlarged glands should not prevent operation being undertaken if the primary disease can be safely removed. When the tumour is rapidly growing and the signs of malignant disease are obvious, radical operation is seldom possible or advisable. Owing to the infiltration of the surrounding tissues, complete removal of the disease might entail resection of portions of the trachea and oesophagus, and such extreme procedures are seldom, if ever, justified. Inoperable cases, however, should not be regarded as necessarily hopeless, as in a proportion of them the growth is radio-sensitive and may disappear completely with X-ray therapy. Operation is, however, occasionally indicated in advanced cases with increasing dyspnoea due to tracheal displacement or compression. When the respiratory embarrassment is such that the patient is in danger of suffocation surgical interference is necessary to give relief. If the patient can be tided over a critical period, X-ray treatment may later be possible. As the trachea is often buried and difficult to find, a radioscopic examination should be made to determine the position of the trachea and the lowest limit of the narrowed portion.

Operation.—Exposure is obtained by a collar incision, and the depressor muscles are divided transversely. If the tumour is confined to one lobe, the whole lobe should be removed. After the middle thyroid vein has been divided between ligatures the upper pole is liberated and the superior thyroid vessels are tied and divided. The lobe is then pulled forwards and medially and the inferior thyroid artery is ligated lateral to the thyroid sheath. The whole lobe is freed, and the inferior thyroid veins are secured. Finally the isthmus is divided well beyond the limit of the disease, and the separation of the lobe from the trachea is completed. The extent of the disease may not be apparent until the operation is undertaken. It is necessary to remove enlarged lymph glands and all muscles and fascia adherent to the growth. If part or the whole of the second lobe is to be removed, the operation is completed without division of the isthmus

When operation is performed for the relief of pressure on the trachea, it is always advisable to attempt to relieve the pressure by

removal of the growth or as much of it as is possible. If this sho
be impossible it is necessary to remove sufficient growth to expose t
trachea and to admit of a tracheotomy tube being introduced. Wh
the constriction is at the thoracic inlet or behind the sternum, a lo
flexible tube may have to be passed beyond the site of compressi

The advisability of these operations for relief of dyspnoea due
pressure on the trachea has been questioned, but we can quote
case in which an emergency tracheotomy was done with immedi
relief, the tumour disappearing subsequently after radiotherapy; a
an unexpected and equally satisfactory result of operation in t
case of an elderly woman in whom respiration had almost entir
ceased as the result of compression by what proved to be not
malignant tumour, as had been diagnosed, but a thyroid cyst, mu
enlarged and rendered tense by haemorrhage within.

The possibility of metastases in early cases must not be forgott
and should be excluded by X-ray examination of the chest and bo
before treatment is undertaken.

Parathyroidectomy

Removal of a parathyroid tumour is sometimes indicated
generalized osteitis fibrosa.

As tumours of the parathyroid are seldom palpable, free exposu
is essential. A wide collar *incision* is made, as for thyroidecton
and, if necessary, the depressor muscles are divided transverse
The whole of the thyroid gland is exposed, and the thyroid sheath
incised over each lobe After the middle thyroid vein has been ti
and divided the corresponding lobe is rotated medially, and t
separation of the thyroid fascia from the capsule covering the post
rior surface of the lobe is completed A tumour of a normally plac
superior or inferior parathyroid may be found. Such a tumour mu
be distinguished from a small adenoma of the thyroid gland. If
tumour is not found in relation to either lobe of the thyroid it shou
be sought for at a lower level on either side of the trachea or in t
superior mediastinum. The removal of a tumour presents lit
difficulty and is not associated with much haemorrhage. When t
parathyroid tumour cannot be found in any of these situations it
probable that it involves one or other of the inferior parathyro
glands which may lie behind the thyroid sheath (Walton). It
necessary, therefore, in such exceptional cases to incise the thyro
sheath on one or on both sides immediately above the level of t
inferior thyroid artery and to search for the tumour alongside t
oesophagus, or within the thorax, where it may have passed dow
behind the oesophagus to rest upon the bodies of the upper thorac
vertebrae.

Thymectomy

The operation of thymectomy has recently been introduced in the treatment of myasthenia gravis. A tumour of the thymus of an epithelial type is present in 10 per cent. of the cases, but in the remaining cases the gland shows no gross abnormality. The most detailed study of the operation and of the results was recorded in 1946 by Geoffrey Keynes.

Operation.—The following description of the operation is based on the technique recommended by Keynes. The anaesthesia of choice is cyclopropane or gas and oxygen with intratracheal intubation. Complete removal of the thymus through an incision in the neck is impracticable, and adequate exposure is obtained only by splitting the sternum. The subcutaneous tissues in the operation area are infiltrated with a solution of adrenaline in the strength of 1 in 500,000 in normal saline. The incision is T-shaped, with a transverse portion above the suprasternal notch and a vertical limb extending downwards in the midline of the sternum to the level of the fourth costal cartilage. The sterno-thyroid muscles are separated and the suprasternal ligament is divided, so that at this stage the upper horns of the thymus, which usually reach the level of the isthmus of the thyroid, can be demonstrated. The left forefinger is pushed down behind the sternum to separate the mediastinal tissues from the back of the bone A small flap of periosteum is raised on each side from the front of the sternum towards the third interspace. This permits a blunt curved dissector to be passed round the edge of the sternum into the mediastinum to separate the pleura from the bone and to meet the finger passed retrosternally from above. The sternum is divided with Schoemaker's sternum splitter down to the level of the fourth costal cartilage, and the bone is then cut transversely with rib shears into the third space on either side. The two halves of the sternum are separated with a strong self-retaining retractor. The bleeding from the cut edges of the bone is not usually severe, but, if necessary, Horsley's wax can be used to control it. The thymus is exposed after a thin film of connective tissue which obscures the mediastinal structures has been divided with scissors in the midline. It is a firm, smooth, pinkish-yellow, bilobed structure, closely applied to the pleurae, which may cover it completely. In the separation of the pleurae, which is required for the full exposure of the gland, the greatest care is necessary to keep them intact because of the great risk of pulmonary collapse. Both lobes of the thymus rest above on the innominate vein, and the upper horns extend into the neck. The lower part of the lobes spreads out over the pericardium to which it is firmly attached. The lobes may also extend for

some distance around the aorta. The gland is separated from the adjacent structures by blunt dissection with careful haemostasis. The venous return is by a short trunk, formed by a tributary from each lobe, which enters the left innominate vein. This venous trunk is of considerable size and must be carefully secured.

After the removal of the gland the two halves of the sternum are approximated and retained in position by two rows of strong catgut sutures placed superficial to the bone Keynes confirms the experience of Dunhill that sutures through the sternum are unnecessary. Finally the skin edges are approximated with clips and fine sutures, and the dressing is maintained with strapping, rather than by bandages which tend to restrict respiratory movement.

Sufferers from myasthenia gravis are muscularly weak and debilitated, and frequently have difficulty in swallowing, in coughing, and in getting rid of their bronchial secretions. They are poor subjects for operation, which should be undertaken, therefore, only by those with special experience.

J. M. G.

CHAPTER XVII

OPERATIONS ON THE PHARYNX AND OESOPHAGUS

Anatomy. Retropharyngeal Abscess. Pharyngeal Pouch. Oesophageal Diverticulum. Cardiospasm. Tracheo-oesophageal Fistula. Carcinoma of Hypopharynx. Carcinoma of Oesophagus.

Anatomy.—The pharynx is a fibro-muscular tube which extends from the base of the skull to the lower border of the cricoid cartilage, where it becomes continuous with the oesophagus. The nasopharynx is concerned with respiration. The pharynx proper, lying below the level of the soft palate, is function-

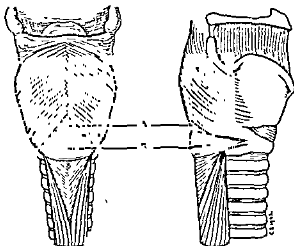


FIG. 113. A. Site of Origin of Pouch between Oblique and Transverse Fibres of Crico-pharyngeus; B. Crico-pharyngeal Sphincter.

ally a part of the alimentary canal. As it descends it gradually narrows, so that in the hypopharynx or post-cricoid area the lumen is reduced to a mere transverse slit.

The [illegible]

wit

in t

be [illegible] into two parts. The lower fibres pass uninterruptedly from side to side to form the cricopharyngeal sphincter, while the upper fibres pass obliquely upwards to join the median raphé on the [illegible]

The opening

potentially

pharyngeus. [illegible] muscles of the pharynx are supplied by the vagi through the pharyngeal plexus, and branches are also received by the inferior constrictor from the external and recurrent laryngeal nerves. The sphincter is controlled by the vagi and by the sympathetic component of the pharyngeal plexus which is derived solely from the superior cervical ganglia. Failure of the sphincter to relax raises the intra-pharyngeal pressure during the act of swallowing, and accounts for one form of dysphagia.

The laryngo-pharynx extends from the superior aperture of the larynx above

to the junction of the hypopharynx with the oesophagus The anterior boundary from above downwards is formed by the epiglottis, the superior aperture of the larynx enclosed by the aryteno-epiglottidean folds with the pyriform fossae lying laterally, while lower down is the plate of the cricoid cartilage.

The oesophagus extends from the cricoid cartilage to the level of the lower end of the sternum. The distance from the teeth to the commencement of the oesophagus is 12 or 15 cm (5 or 6 in) and, as the oesophagus measures from 22 to 25 cm. (9 to 10 in.), the distance from the teeth to the stomach is from 34 to 40 cm. (14 to 16 in.)

The cervical portion of the oesophagus extends to the upper margin of the sternum and measures about 5 cm. (2 in.) It lies behind and slightly to the left of the trachea, with the recurrent nerve in the groove between them on each side. The thoracic portion traverses the posterior mediastinum with a slight inclination to the right at the level of the aortic arch, and a more definite deviation to the left in the lower part. It is crossed by the left bronchus, and below this has the pericardium in front of it. The mediastinal pleura on the right side is in close relation to the thoracic oesophagus throughout its length. On the left side the oesophagus is separated from the pleura only by the arch of the aorta Towards the lower end the left pleura may extend behind the oesophagus and come almost in contact with the right pleura These relations explain the tendency to invasion of the pleura, by carcinoma arising in the thoracic oesophagus and the risk, always present in operations on this part of the oesophagus, of opening the pleura on one or other side. The abdominal portion of the oesophagus from the hiatus in the diaphragm to the cardiac opening in the stomach is 2·5 cm. (1 in) or slightly more in length. No anatomical sphincter is present at the lower end of the oesophagus, but the circular muscle fibres of the inter-diaphragmatic and abdominal portions function as an intrinsic sphincter, which is relaxed by the vagus and contracts on sympathetic stimulation

There are three points at which the oesophagus shows narrowing of the lumen: (1) at the lower border of the cricoid, (2) where it is crossed by the left bronchus, and (3) where it passes through the diaphragm.

The muscular coat of the oesophagus consists of an outer longitudinal and an inner circular layer which becomes continuous with the corresponding circular muscular layer of the stomach In the upper third the fibres are striated, while in the distal two-thirds they are non-striated. The mucous membrane is insensitive to tactile stimuli, but is sensitive to heat and cold and to exaggerated peristalsis. In cases of dysphagia the patient can often locate the site of the stenosis.

The arterial supply to the oesophagus is derived from the inferior thyroid arteries in the neck, from small branches of the aortic, intercostal, and bronchial arteries in the thorax, and from the left inferior phrenic and the oesophageal branch of the left gastric artery from below the diaphragm The arterial supply is sufficient for most surgical procedures. It is least satisfactory in the lowest part of the oesophagus above the diaphragm.

The nerve-supply to the oesophagus is entirely autonomic through the vagi and the sympathetic system The recurrent nerves supply the cervical oesophagus, while the thoracic portion receives numerous small filaments from both vagi. According to Knight, the oesophagus receives a few direct branches [illegible]

[illegible]

[illegible]

solely from below the diaphragm from the coeliac plexus along the oesophageal branch of the left gastric artery. Mitchell has shown by numerous dissections

that the lower end of the oesophagus receives its sympathetic supply from the ganglionated cords between the sixth and ninth or tenth thoracic ganglia, from the greater and occasionally the lesser splanchnic nerves, as well as from the plexus around the left gastric and inferior phrenic arteries.

Retropharyngeal Abscess.—A tuberculous abscess in the retropharyngeal space should be opened from the outside by an incision made along the posterior border of the sterno-mastoid, as was first suggested by John Chiene. After the skin and fascia have been divided, and the superficial cervical nerves and the external jugular vein identified and held aside, the sterno-mastoid is drawn forward. The omohyoid is defined and cut across, and the internal jugular vein drawn forward with a broad retractor. The scalchi are thus exposed, and the abscess can be seen or felt in front of the vertebrae. A blunt instrument is now pushed through the deep fascia into the cavity, and the pus and tuberculous debris are removed. The external wound is closed without drainage.

The more acute pyogenic forms occurring in children may be opened from the mouth, provided care is taken that the pus is not allowed to enter the air-passage. The mouth is opened by means of a gag, the head being allowed to hang over the end of the table, and the point of a guarded bistoury, guided along the index finger, is passed into the abscess.

Pharyngeal Pouch.—Resection of the pouch may be done in one or in two stages The two-stage method is employed by the majority of surgeons, but there are others, equally experienced, who prefer to resect the pouch in one stage, or who perform a two-stage operation only in the case of the larger pouches. With the two-stage procedure there is less risk of serious infection of the cellular planes of the neck. The operation of diverticulopexy, described by Hill in 1918, has a more limited scope, and is indicated only in the case of frail and elderly patients whose symptoms demand relief with the minimum of risk.

Preliminary Treatment.—When the patient is under-nourished and dehydrated, saline and glucose should be given in adequate amounts by the intravenous route before the operation If the patient is actually suffering from starvation a longer preparation is needed; for this purpose a gastrostomy is occasionally necessary, but preferably the patient is fed through an oesophageal tube left *in situ* after it has been passed by a laryngologist. Before the operation the pouch should be emptied by pressure or by suction through an oesophagoscope. Cyclopropane, or gas and oxygen given endotracheally, is the anaesthetic of choice.

Exposure.—The exposure of the sac is similar in all three procedures. The incision is made along the anterior border of the left

sterno-mastoid muscle from the level of the hyoid bone to a point immediately above the clavicle. In the case of a pouch projecting more to the right of the midline, the incision should be made on the right side of the neck. The omohyoid muscle is divided, and the sterno-mastoid and carotid sheath with its contents are retracted laterally. After division and ligation of the middle thyroid vein, the lateral lobe of the thyroid is freed and pulled anteriorly, and may have to be removed if it is enlarged. The inferior thyroid artery may require ligation and division.

The lateral edge of the sac is usually seen when the pretracheal fascia has been divided, but if it is not at once obvious it can be located by the passage of a stomach-tube, which invariably enters the pouch. The separation of the pouch upwards from the back of the oesophagus is readily accomplished. The neck of the sac must be thoroughly freed from the connective tissue binding it to the oesophagus. Gentle traction on the pouch and rotation of the oesophagus will enable the opposite side of the neck of the sac to be cleared. Care must be taken not to wound the junction of the pouch with the pharynx, and to avoid injury to the recurrent nerves. When the pouch is held upwards after it has been completely freed a stomach-tube can easily be passed into the oesophagus.

The operation is completed by anchoring the pouch in an inverted position (*diverticulopexy*) The fundus is fixed by several fine silk sutures to the pre-thyroid muscles in a position which will maintain it at as high a level as possible above the opening in the pharynx without undue tension A strip of dental rubber is left in the space formerly occupied by the pouch.

One-stage Resection.—After the sac has been removed the neck is closed by suture, by transfixion and ligature, or by a modified cuff technique which leaves a redundant portion of the fascial coat to be sutured over the mucosal stump. Care must be taken to avoid encroaching on the pharyngeal mucosa by undue traction.

Two-stage Resection—The first stage is completed by the fixation of the pouch high in the neck as described above in the operation of diverticulopexy If the pouch is unusually large the fundus is stitched to the skin edges at the upper angle of the wound. Removal of the pouch is postponed for ten to fourteen days, by which time the lymphatics of the tissue spaces have become sealed In the interval the sac tends to shrink, while the outer coat becomes thickened by oedema. There may be difficulty in locating a small sac at the second operation unless the level at which the fundus was fixed has been noted

The sac is dealt with by the method described by Wilkie and Hartley, which consists in a submucous resection of the mucosal

lining without opening up the tissue planes of the neck. As the mucosa is loosely attached it can readily be separated from the fascial coat. After the fundus has been exposed the top of the sac is

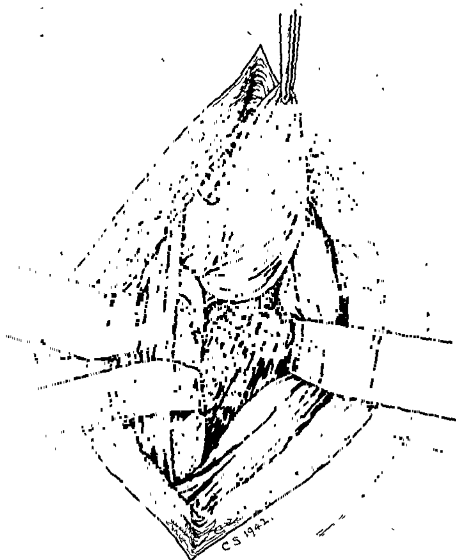


FIG 114 Shows displacement upwards of Pouch after it has been freed from its original position.

removed and the mucosal lining is stripped by blunt dissection from the outer coat to its junction with the pharynx. The mucosal tube is divided a short distance proximal to the level of its junction with the pharynx and closed by purse-string suture or by interrupted stitches as appears indicated. The surfaces of the fascial coat adjacent to the stump are sutured together to reinforce the closure. A

sterno-mastoid muscle from the level of the hyoid bone to a point immediately above the clavicle. In the case of a pouch projecting more to the right of the midline, the incision should be made on the right side of the neck. The omohyoid muscle is divided, and the sterno-mastoid and carotid sheath with its contents are retracted laterally. After division and ligation of the middle thyroid vein, the lateral lobe of the thyroid is freed and pulled anteriorly, and may have to be removed if it is enlarged. The inferior thyroid artery may require ligation and division.

The lateral edge of the sac is usually seen when the pretracheal fascia has been divided, but if it is not at once obvious it can be located by the passage of a stomach-tube, which invariably enters the pouch. The separation of the pouch upwards from the back of the oesophagus is readily accomplished. The neck of the sac must be thoroughly freed from the connective tissue binding it to the oesophagus. Gentle traction on the pouch and rotation of the oesophagus will enable the opposite side of the neck of the sac to be cleared. Care must be taken not to wound the junction of the pouch with the pharynx, and to avoid injury to the recurrent nerves. When the pouch is held upwards after it has been completely freed a stomach-tube can easily be passed into the oesophagus.

The operation is completed by anchoring the pouch in an inverted position (*diverticulopexy*). The fundus is fixed by several fine silk sutures to the pre-thyroid muscles in a position which will maintain it at as high a level as possible above the opening in the pharynx without undue tension. A strip of dental rubber is left in the space formerly occupied by the pouch.

One-stage Resection.—After the sac has been removed the neck is closed by suture, by transfixion and ligature, or by a modified cuff technique which leaves a redundant portion of the fascial coat to be sutured over the mucosal stump. Care must be taken to avoid encroaching on the pharyngeal mucosa by undue traction.

Two-stage Resection.—The first stage is completed by the fixation of the pouch high in the neck as described above in the operation of diverticulopexy. If the pouch is unusually large the fundus is stitched to the skin edges at the upper angle of the wound. Removal of the pouch is postponed for ten to fourteen days, by which time the lymphatics of the tissue spaces have become sealed. In the interval the sac tends to shrink, while the outer coat becomes thickened by oedema. There may be difficulty in locating a small sac at the second operation unless the level at which the fundus was fixed has been noted

The sac is dealt with by the method described by Wilkie and Hartley, which consists in a submucous resection of the mucosal

bifurcation of the trachea, and the traction diverticulum at the same level, are usually only of pathological interest.

A rare type of pulsion diverticulum also occurs in the oesophagus, particularly in the lower third a short distance above the diaphragm, where it may project to one or other side, usually towards the right. This type of diverticulum is usually referred to as an epiphrenic diverticulum, and may be responsible for symptoms requiring operation.

The diverticulum can readily be exposed through a transpleural incision on either side, according to its position. It may then be removed in one stage by a technique similar to that used for a pharyngeal pouch. Owing to the serious risks associated with possible subsequent leakage, special care is necessary in such cases to overlap the mucosal stump with redundant portions of the outer fascial coat at the neck of the diverticulum. As an alternative procedure Lahey has successfully treated this type of diverticulum by the operation of diverticulopexy, displacing the fundus to a higher level where it is fixed by sutures to the pleura of the chest wall.

Other procedures recorded have been anastomosis between the diverticulum and the oesophagus distally, and, on the left side, anastomosis between the diverticulum and the stomach, which has been brought up through an opening in the diaphragm.

Cardiospasm—Achalasia of the Oesophagus.—Operation is indicated if palliative treatment with the mercury bougie, or some other form of dilator such as Plummer's hydrostatic bag, has failed to relieve the dysphagia There is a choice of several procedures:—

(1) *Digital Dilatation* (Mikulicz) —After the induction of anaesthesia the oesophagus should be emptied by suction through an oesophagoscope The stomach is opened through a longitudinal incision placed between the two curvatures. The index finger is passed up into the oesophagus, then the middle finger is introduced, and finally, after some stretching, the ring finger is also inserted, the lower end of the oesophagus being gradually dilated. The force exerted by abduction of the fingers within the lumen is less than might be expected, and much less dangerous than by any form of instrumental dilatation The incision in the stomach is closed by three rows of sutures in the usual way.

The operation can never be perfectly aseptic, and there is not infrequently some infection of the wound. This method, however, gives good results, and a considerable proportion of the patients are permanently relieved of their dysphagia.

(2) *Oesophago-gastrostomy.*—This is an operation which gives excellent results, but is technically more difficult than some of the

strip of dental rubber is inserted within the fascial sheath, and the skin incision is partly closed around the drain. If the pouch is small part of the fascial sheath can be removed and the remaining portion

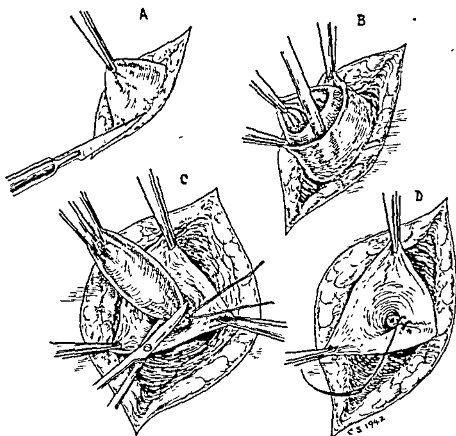


FIG 115 Resection of Pouch in second stage.

A Exposure of fundus
B Top of sac removed, submucous dissection of mucosal lining commenced.
C Ligation of mucosal tube close to its junction with pharynx
D Suture of fascial sheath over mucosal stump

overlapped and sutured over the mucosal stump to reinforce the weak area in the pharyngeal wall

After-treatment —After diverticulopexy or a first-stage operation the patient is able to swallow fluids freely within a few hours, and can take a normal diet within a few days. After resection of the pouch the patient can be allowed to swallow sterile water after twenty-four hours, but should be kept on fluids and soft foods for a week.

Oesophageal Diverticulum.—The congenital type of diverticulum which occurs in the anterior wall of the oesophagus near the

verse incision is made in the peritoneum below the hiatus in the diaphragm, and the lower end of the oesophagus is isolated. By blunt dissection the lower part of the thoracic portion is freed within the hiatus and for a short distance above it, so that by traction 5–8 cm. (2–3 in.) of the dilated oesophagus can be brought down below the level of the diaphragm (Fig. 116). The oesophagus is united to the seromuscular coat of the fundus of the stomach by a vertical row of interrupted linen stitches extending upwards from a point immediately above the cardia for a distance of 6 cm. (2½ in.). Longitudinal incisions are then made in the stomach and in the oesophageal wall down to the level of the mucosal coats, and a second layer of sutures is inserted. Following this the lumen on either side is opened and a third layer of stitches is introduced to unite the edges of the mucosal coats. The anastomosis is completed by similar layers of sutures placed anteriorly, and finally the edges of the peritoneum are sutured together over the area of the anastomosis.

The transpleural route is selected only if such adhesions are anticipated as would make the exposure by the abdominal route especially difficult, or in the rare case in which a Heller's operation has already been performed, but without success, rendering a repetition of the procedure or an attempt at digital dilatation impossible or dangerous.

Exposure is obtained through a long incision in the seventh left intercostal space. The lower part of the thoracic oesophagus having been isolated by blunt dissection, the diaphragm is incised radially towards and, if necessary, into the hiatus, so that the fundus of the stomach may be brought up to a sufficient extent to lie without tension beside the oesophagus. The anastomosis is then made as previously described, leaving a vertical opening about 4 cm. (1½ in.) in length The omentum is sutured around the anastomosis, and the incision in the diaphragm is repaired, leaving only sufficient space for the passage of the fundus, to which the edges of the gap are securely anchored by interrupted linen sutures. Provision is made for drainage, and after the lung has been expanded the incision in the chest wall is closed.

(3) *Oesophago-cardiomyotomy* (Heller's operation) (Fig. 117).—This [illegible]

[illegible] including the muscular fibres of the stomach at the cardia. After the circular muscular coat has been divided the muscle fibres retract on both sides allowing the mucous membrane to bulge forwards, so that the sphincteric action is abolished. The operation must be done with great care, as the

other procedures. The anastomosis is made preferably below the diaphragm, but it can also be done by the transpleural route.

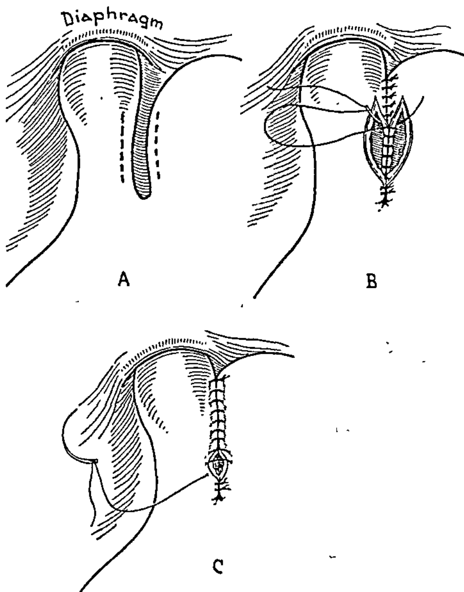


FIG 116 Oesophago-gastrostomy.

A Incisions in Oesophagus and Stomach
B Anastomosis of posterior layers
C Anastomosis completed by anterior sutures

Access is obtained for the operation below the diaphragm through
on of the oesophagus
to the right and by
direction A trans-

verse incision is made in the peritoneum below the hiatus in the diaphragm, and the lower end of the oesophagus is isolated. By blunt dissection the lower part of the thoracic portion is freed within the hiatus and for a short distance above it, so that by traction 5-8 cm. (2-3 in.) of the dilated oesophagus can be brought down below the level of the diaphragm (Fig. 116). The oesophagus is united to the seromuscular coat of the fundus of the stomach by a vertical row of interrupted linen stitches extending upwards from a point immediately above the cardia for a distance of 6 cm. (2½ in.). Longitudinal incisions are then made in the stomach and in the oesophageal wall down to the level of the mucosal coats, and a second layer of sutures is inserted. Following this the lumen on either side is opened and a third layer of stitches is introduced to unite the edges of the mucosal coats. The anastomosis is completed by similar layers of sutures placed anteriorly, and finally the edges of the peritoneum are sutured together over the area of the anastomosis.

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(3) *Oesophago-cardiomyotomy* (Heller's operation) (Fig. 117).—This [illegible]

[illegible] about 5 cm. (2 in.) including the muscular fibres of the stomach at the cardia After the circular muscular coat has been divided the muscle fibres retract on both sides allowing the mucous membrane to bulge forwards, so that the sphincteric action is abolished. The operation must be done with great care, as the

oesophageal mucosa is thin and there is always a risk of its being accidentally opened.



FIG. 117. Oesophago-cardiomyotomy (Heller's Operation. Inset shows Method of Separating Muscle Flaps)

A left paramedian incision is made, extending upwards to a point close to the xiphisternum. The left lobe of the liver is retracted to the right and, if necessary, is mobilized by division of the left lateral

ligament. The lower end of the oesophagus is exposed by gentle traction on the stomach, and the exposure is completed by division of the peritoneum either in the long axis of the oesophagus or by a transverse incision below the hiatus. The left vagus nerve is retracted medially. By traction on the oesophagus 2-5 cm. (1-2 in.) of its thoracic portion can be brought below the level of the diaphragm; if necessary to accomplish this, the oesophagus should be freed by blunt dissection so that the finger can be placed around it for gentle traction. An incision is then made in the long axis above the junction of the oesophagus with the stomach, splitting the longitudinal fibres and dividing the circular muscle fibres, a procedure which must be carried out with great care as the muscular coats are thin and show no sign of hypertrophy. Once the mucosa has been exposed the subsequent division of the circular muscle-coat is simplified by inserting beneath it the points of a fine curved artery forceps, the separation of which enables successive portions of the circular muscular coat to be divided safely for approximately 5 cm. (2 in.) in an upwards direction. A similar procedure is completed in the lower part until the gastric mucosa is exposed for approximately 2·5 cm. (1 in.) beyond the junction of the oesophagus with the stomach. As a rule only a few small vessels require to be secured and tied.

The success of the operation depends upon the completeness with which the circular muscular coat is divided up to a point at least as high as the upper level of the opening in the diaphragm. The patient can safely be allowed to swallow fluids within twenty-four hours of the operation, and thereafter is soon able to take a normal diet.

Congenital Tracheo-oesophageal Fistula.—The commonest type of congenital malformation is one in which the upper end of the oesophagus ends blindly and the lower end communicates through a fistulous track with the trachea, as the result of which the infant dies within a few days from starvation and inhalation pneumonia. The operation of gastrostomy will not postpone death from pulmonary infection, and the interruption of the fistulous track is essential in an attempt to preserve life. Leven and Ladd independently have described a series of operations which have been successful in a few cases A gastrostomy is first performed, in which the end of the catheter is passed through into the duodenum; without this precaution in the infant spasm of the pylorus and regurgitation are almost sure to result from the presence of a catheter in the stomach. The next step of the operation consists in the subperiosteal resection of the fourth rib on the right side and the extrapleural exposure of the region of the bifurcation of the trachea, sufficient to allow the fistulous track to be doubly ligated and divided. In exceptional cases, when the two blind ends of the oesophagus are sufficiently

close together, Ladd has succeeded in carrying out an end-to-end union. For a few days subsequently the pharynx and blind upper end of the oesophagus are kept free of saliva and mucus by repeated aspiration. When the child has recovered sufficiently the oesophagus is then exposed by incision on the left side of the neck, and by blunt dissection the blind upper thoracic portion is freed and brought up to be transplanted into the root of the neck or below the clavicle, if it is long enough. At a subsequent date the opening in the stomach and the cervical opening of the oesophagus are joined by a skin tube.

Pharyngotomy.—*The operation of pharyngotomy is performed* to gain access to the pharynx either for the removal of a growth or for the local application of radium. The method employed is determined in each case by the situation and extent of the growth. The risk common to all methods is local infection of the wound and infection of the lungs. To minimize the risk of local infection the mouth should be cleansed prior to the operation and all carious teeth extracted. The risk of infection of the lungs is diminished by the employment of intratracheal anaesthesia, and in certain cases by the performance of a preliminary tracheotomy.

Median Trans-lingual Pharyngotomy—This operation was recommended by Wilfred Trotter for growths of the epiglottis or glosso-epiglottic fossa. A preliminary tracheotomy is performed and the pharynx is plugged A midline incision is made through the lower lip, over the chin and the submental region as far as the top of the thyroid cartilage. The incision is deepened between the mylohyoid and the genio-hyoid muscles, and these muscles are separated in the midline. The mandible is divided and the two halves are widely separated The tongue is then split in the midline to its base. The growth is removed by cutting laterally, separating it from the base of the tongue, dividing the ary-epiglottic folds, the epiglottis, and the body of the hyoid bone. The split tongue is now repaired, and the wound is closed by deep-buried catgut and skin sutures, the submental part of the skin incision being left open for drainage.

Lateral Trans-thyroid Pharyngotomy (Trotter)—This is the method of choice in the epilaryngeal forms of carcinoma, which are common in men, and involve the lateral wall of the pharynx, the aryteno-epiglottidean fold, or the pyriform sinus. The anatomical basis of the operation is the fact that the pharynx is protected laterally by the thyroid ala, the great cornu of the hyoid bone, and the thyro-hyoid ligament. These structures can be detached, leaving the wall of the pharynx exposed and unopened The growth within can then be palpated and its limits defined. A preliminary tracheotomy is done. A vertical incision is made from the angle of the jaw downwards for 10–12 cm. (4–5 in). The anterior margin of the sterno-

mastoid is defined and the muscle retracted backwards. The deep cervical chain of lymph glands is excised and, if necessary, the internal jugular vein removed. The superior thyroid artery is ligated and divided. The anterior edge of the sterno-mastoid muscle is brought over the carotid vessels and sutured with catgut to the prevertebral muscles. A vertical incision is now made over the lateral aspect of the larynx, and the attachments of the sterno-thyroid, thyro-hyoid, and inferior constrictor muscles are separated from the ala of the thyroid cartilage, which is exposed by retracting the infra-hyoid muscles forwards and the inferior constrictor muscle backwards. The great cornu of the hyoid bone is cleared and the deep surface of the thyroid ala is separated from the underlying pharynx by blunt dissection. Free access to the lateral wall of the pharynx is obtained after removal of the great cornu of the hyoid and of the posterior two-thirds of the thyroid ala, and by division of the thyro-hyoid membrane with the sacrifice, if necessary, of the superior laryngeal artery and nerve. The growth is now felt and the pharynx opened through a suitable incision. The tumour is then removed.

The after-treatment depends on the extent of the removal. The pharynx may be closed or left open with its mucous membrane sutured to the skin.

Reconstruction of the Pharynx by Skin-flap (Trotter's Operation).—This operation is performed in cases of carcinoma of the hypopharynx or post-cricoid area and of the posterior wall of the laryngo-pharynx. Closure of the gap left after removal of a segment of the gullet or of a growth on the posterior wall is impossible, and a skin-flap is necessary for reconstruction of the pharynx.

A tracheotomy is performed through a short transverse incision placed as low as possible above the supra-sternal notch. The trachea is opened by removal of a circle of cartilage sufficient to permit the easy introduction of the tracheotomy tube, the lower part of the flange of which has been removed by the instrument-maker to prevent pressure on the skin.

A rectangular flap is outlined with its base over the left sterno-mastoid muscle and extending for 5 cm. (2 in.) to the right of the midline. The upper margin of the flap is at the level of the hyoid bone, and the lower margin is immediately above the tracheotomy opening. After reflection of the skin-flap the dissection is continued on the lines described in the operation of lateral trans-thyroid pharyngotomy. It is necessary, however, to expose and to free the cervical oesophagus as well as the hypopharynx, after the greater part of the thyroid ala has been removed. For a carcinoma at this level, removal of the great cornu of the hyoid and division of the

thyro-hyoid membrane are not usually required. The extension of a growth from the hypopharynx to the oesophagus is usually strictly limited. The inferior constrictor muscle is divided and the lower end of the pharynx separated from the back of the cricoid. A complete

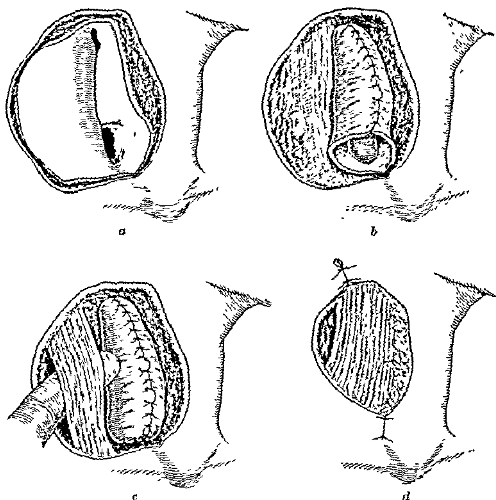


FIG 118 Showing Stages in Reconstruction of Gullet by Tube of Skin

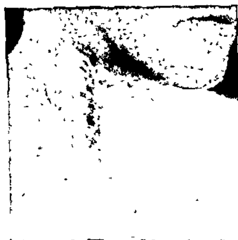
a Incision in skin
b Construction of tube
c Mobilization of sterno-mastoid
d Suture of sterno-mastoid over tube, and closure of skin

segment of the hypopharynx, including the upper end of the oesophagus, is removed The skin-flap is depressed into the space between the sterno-mastoid and the larynx and trachea, and is sutured above to the posterior edge of the opening in the pharynx and below to the corresponding edge of the divided end of the oesophagus The anterior edges of the cut ends of pharynx and oesophagus are then

fixed by catgut sutures to the margins of the surrounding skin. By undermining the skin on the right side of the neck the gap left by the transposition of the skin-flap is covered over. A stomach-tube is introduced into the oesophagus for feeding purposes. After this stage of the operation a deep skin gutter is left in the side of the neck communicating with the pharynx above and with the oesophagus below. The tracheotomy tube, which ensures against the risk of post-operative oedema at the opening of the larynx, can usually be removed within a few days.



a



b

FIG 119. Reconstruction of Pharynx by Skin-flap.

a Showing result after interposition of skin-flap between openings in pharynx above and oesophagus below. b. Operation completed.

Reconstruction of the Gullet (Fig 118).—The patient can be kept in good condition by feeds given through the oesophageal opening. There is some inconvenience from the escape of saliva through the upper opening, but it is wise to postpone the reconstruction for several months. The constant pressure of a length of rubber tubing in the upper end of the oesophagus ensures a wide and well-stretched opening at the junction of skin and oesophageal mucosa, at which site there is otherwise a tendency for a stricture to develop after the skin tube has been completed.

To reconstruct the gullet an incision is made around the upper margin of the [illegible]

[illegible] the edges of the gutter. A large stomach-tube is now passed from the mouth into the oesophagus, so that the portion of the tube lying in the gutter will provide a mould around which the skin can be folded. The skin is then elevated on both sides and around the openings to a sufficient extent to allow

the edges to be sutured with catgut over the stomach-tube. Some adjustment may be needed to ensure that no pockets are left where the skin tube joins the mucosa of the pharynx and oesophagus. It is usually possible, by undermining the surrounding skin, to bring the edges together and to cover completely the reconstructed gullet.

We have one patient, on whom this operation was performed twenty years ago, who takes a normal diet, including solids of all kinds, and who swallows perfectly.

Carcinoma of the Oesophagus.—Although in certain cases of carcinoma of the oesophagus improvement in swallowing is observed after irradiation, particularly in cases of carcinoma of the middle third treated by radium bougie, the final results have so far been disappointing, and in recent years there has been an increasing tendency to recommend operation. Already with improved technique a number of encouraging results have been recorded, and the details of operation must therefore be considered.

From a study of 8,000 cases Ochsner states that cancer occurs in the upper third of the gullet, including the hypopharynx, which is a commoner site than the cervical oesophagus, in 20 per cent., and in the middle or lower third of the oesophagus, in 80 per cent. of the cases. The growth is present in the middle third, usually at the level of the aortic arch or close to the crossing of the left bronchus, in 37·2 per cent. of the cases, while in the remaining 42·8 per cent. the lower third is involved. In the latter situation the growth may arise in the oesophagus or may be an extension from a carcinoma of the cardiac end of the stomach

Oesophagectomy for Carcinoma of the Upper Third of the Oesophagus.—When the cervical portion of the oesophagus is to be resected a skin-flap must be provided for subsequent reconsfruction, as in the operation for carcinoma of the hypopharynx.

The operation is performed under endotracheal anaesthesia The oesophagus is exposed from the left side of the neck, with the base of the skin-flap placed over the left sterno-mastoid muscle. After the reflection of the flap the omohyoid muscle is divided, and the sterno-mastoid muscle and the carotid sheath with its contents are retracted laterally The middle thyroid vein is then ligated and divided, and the lateral lobe of the thyroid is freed and pulled forwards. The inferior thyroid artery also is ligated and divided. If necessary, to afford better exposure, the left lobe of the thyroid is excised. The recurrent laryngeal nerve is seen and protected. The cleft between the larynx, trachea, and oesophagus is defined, and the fascia uniting them is divided. If the growth in the oesophagus is too extensive for complete removal, the operation should be concluded at this stage. When the conditions are favourable for a radical operation, the

upper end of the oesophagus is separated from the trachea, and the whole of the cervical oesophagus is then mobilized. The oesophagus is divided first above, close to its junction with the pharynx. By gentle traction the lower part of the oesophagus below the growth is then exposed and divided, care being taken to secure the lower divided end to prevent its retraction. The open ends of the pharynx and of the oesophagus are sutured to the skin and to the edges of the skin-flap, as described in the operation for carcinoma of the hypopharynx. The patient is fed through a portion of stomach-tube inserted through the oesophageal opening The reconstruction of the skin tube is completed after an interval of several months.

Carcinoma of the Middle and Lower Thirds.—The growth may be inoperable from extension of the carcinoma to the neighbouring structures, or from spread to the lymph glands. Abel has shown in a post-mortem series that 25 per cent. of the cases of carcinoma of the oesophagus were still operable, and it is natural to conclude, therefore, that a higher percentage of cases would be operable when first seen clinically. In a series of 65 cases of epithelioma of the oesophagus exposed at operation, Garlock found it possible to resect the growth in 29, or 44 per cent. of the cases. As the patients are frequently in poor condition a considerable mortality is to be expected, and consequently the operation should be undertaken only by those with special experience.

The methods employed vary in the different situations. For the middle third they are based mainly on the original operation of Torek, whose patient survived for eleven years. This method entails a transpleural approach to the oesophagus, preferably from the right side, and transposition of the proximal end of the oesophagus to the neck. A preliminary gastrostomy or jejunostomy is necessary. The subsequent reconstruction of the oesophagus by a skin tube is a difficult and tedious procedure which may end in failure.

The approach for growths of the lower end of the oesophagus, as well as for tumours arising in the cardiac end of the stomach, is through a transpleural incision on the left side followed by an immediate anastomosis of the oesophagus to the stomach, which is brought up into the thorax through an incision in the diaphragm. A similar operation has been successfully performed by Garlock for carcinoma of the oesophagus as high as the aortic arch, but it must be stated that it is as yet uncertain in what proportion of cases the stomach can be brought up for anastomosis at such a high level without undue tension.

The posterior mediastinal approach of Lilienthal is no longer recommended Experience has shown that by this route there is always a risk of tearing the pleura, to avoid which was the original

intention of the operation, and that the exposure of the oesophagus is too restricted.

Pre-operative Treatment.—The patient is prepared for the major operation with intravenous fluids as required, and a course of penicillin is commenced on the day previous to operation. It is advisable also to arrange for an intravenous drip of glucose and saline to be given at a slow rate during the operation, so that if necessary blood can be run in at any time.

Oesophagectomy for Carcinoma of the Middle Third (Harold Wookey).—*Stage I.* The operation is performed in stages, the first of which consists of a laparotomy and the formation of a jejunostomy of the Witzel type through an incision near the midline. The jejunostomy is necessary for feeding the patient during the subsequent stages of the operation.

Stage II. Two or three weeks later the cervical oesophagus is exposed and freed through an incision on the left side of the neck. This step is intended to save time and to facilitate the delivery of the oesophagus through the neck when the oesophagus is resected.

Stage III. For the third stage, five days later, anaesthesia is given by intratracheal tube, preferably with cyclopropane. As shown by Wookey, the resection is much more easily performed when the incision is made on the right side. The patient is therefore placed on the left side with the right arm drawn forwards and supported on an arm-rest, and a long incision is made over the seventh intercostal space. The pleura is opened in front and then throughout the whole length of the incision, allowing the lung to collapse slowly, and with the aid of a rib-spreader the edges of the wound are widely separated If the exposure is limited, the seventh and eighth ribs should be divided subperiosteally as far back as possible. After the lung has been gently displaced forwards the oesophagus can be seen and felt, and is readily exposed by incision of the mediastinal pleura If removal of the tumour is possible the vena azygos is doubly tied and divided as it arches over the oesophagus The oesophagus is freed above and below the tumour, which is then separated from the surrounding structures, special care being taken to avoid damage to the left pleura The separation of the oesophagus in the upper limit of the thorax is accomplished by blunt dissection, and this is continued until contact is made with the part previously exposed in the neck. The aorta and the superior vena cava are much less obvious than when the approach is made through the left pleural sac, and they offer no special difficulty in the dissection The oesophagus is now doubly ligated and divided well below the tumour, and the lower end is invaginated with a purse-string suture reinforced by one or more additional stitches. The upper end is covered with a finger-stall

which is fixed in position by several ligatures. Closed drainage of the pleural space is established by a rubber tube introduced through a short incision in the tenth intercostal space in the mid-axillary line.

If for any reason the operation is likely to be prolonged, it is advisable occasionally to withdraw the rib-spreader and to allow the anaesthetist to inflate the lung by positive pressure, as there is a tendency for the re-expansion of the lung to be incomplete if it has remained collapsed over a considerable period. To complete this part of the operation the lung is finally expanded by positive pressure, and the wound is closed after interrupted catgut sutures have been placed around the ribs.

The patient is now turned over on to his back. The wound in the neck is opened and the oesophagus with the tumour is brought out on to the surface. In the case of bulky tumours delivery through the neck incision would be difficult or impossible, and therefore, if necessary, the oesophagus may previously be ligated and divided above the growth which is then removed from within the thorax. After delivery of the oesophagus and division above the tumour, the cut end is brought out at the lower angle of the wound in the neck and sutured to the skin without tension. If long enough it is brought out through a short, subcutaneous tunnel to below the clavicle, where the open end is sutured to a suitable incision in the skin.

Stage IV. The fourth stage, which consists in bringing the lower end of the oesophagus to the surface, is postponed until the patient has recovered from the resection. Through an oblique incision below the left costal margin the oesophagus is freed at the hiatus, and after some blunt dissection the lower invaginated portion is brought below the diaphragm. A length of 8 cm. (3 in.) is sufficient to allow the proximal end of this portion to be brought to the surface and stitched to the skin below the costal margin, to provide an opening which can later be joined by a skin tube to the upper end of the oesophagus.

Stage V. After an interval a strip of skin 6 cm. ($2\frac{1}{2}$ in.) in width is outlined by incisions extending between the open ends of the oesophagus. The skin on either side is freed sufficiently to permit the edges to be brought together by interrupted catgut sutures, and the ends of the tube thus formed are later sutured to the freshened edges of the oesophagus above and below. By undercutting the skin on either side the margins are sufficiently freed to be sutured together over the reconstructed gullet.

When the lower end of the oesophagus is too short to be brought to the surface, some other method of joining the skin tube to the stomach must be selected. A simple gastrostomy opening, however large, cannot as a rule be satisfactorily united to the skin tube. A

intention of the operation, and that the exposure of the oesophagus is too restricted.

Pre-operative Treatment.—The patient is prepared for the major operation with intravenous fluids as required, and a course of penicillin is commenced on the day previous to operation. It is advisable also to arrange for an intravenous drip of glucose and saline to be given at a slow rate during the operation, so that if necessary blood can be run in at any time.

Oesophagectomy for Carcinoma of the Middle Third (Harold Wookey).—*Stage I.* The operation is performed in stages, the first of which consists of a laparotomy and the formation of a jejunostomy of the Witzel type through an incision near the midline. The jejunostomy is necessary for feeding the patient during the subsequent stages of the operation.

Stage II. Two or three weeks later the cervical oesophagus is exposed and freed through an incision on the left side of the neck. This step is intended to save time and to facilitate the delivery of the oesophagus through the neck when the oesophagus is resected

Stage III. For the third stage, five days later, anaesthesia is given by intratracheal tube, preferably with cyclopropane. As shown by Wookey, the resection is much more easily performed when the incision is made on the right side The patient is therefore placed on the left side with the right arm drawn forwards and supported on an arm-rest, and a long incision is made over the seventh intercostal space. The pleura is opened in front and then throughout the whole length of the incision, allowing the lung to collapse slowly, and with the aid of a rib-spreader the edges of the wound are widely separated. If the exposure is limited, the seventh and eighth ribs should be divided subperiosteally as far back as possible. After the lung has been gently displaced forwards the oesophagus can be seen and felt, and is readily exposed by incision of the mediastinal pleura. If removal of the tumour is possible the vena azygos is doubly tied and divided as it arches over the oesophagus. The oesophagus is freed above and below the tumour, which is then separated from the surrounding structures, special care being taken to avoid damage to the left pleura The separation of the oesophagus in the upper limit of the thorax is accomplished by blunt dissection, and this is continued until contact is made with the part previously exposed in the neck. The aorta and the superior vena cava are much less obvious [illegible]

[illegible]

doubly [illegible] end is invaginated with a purse-string suture reinforced by one or more additional stitches. The upper end is covered with a finger-stall

epiploic arteries are left intact. Two pairs of Schoemaker's clamps are applied to the oesophagus above the growth, and distally Payr's clamps are placed at the cardiac end, or across the stomach at a safe level beyond the growth. The division between the clamps is made with a knife. The divided end of the stomach is closed and invaginated with two rows of sutures, and the parts are then arranged for an end-to-side anastomosis between the oesophagus and the anterior surface of the stomach well below its upper limit. Two rows of interrupted linen sutures are used for the anastomosis. The end of the oesophagus is rotated by the clamp to facilitate the introduction of the posterior row of sutures; the clamp is then removed and a suitable incision is made in the anterior wall of the stomach. Suction should be available in case of leakage. The mucosal edges are accurately sutured together, and the junction is completed by an anterior row of sutures between the muscular and submucous coats of the oesophagus and the seromuscular coat of the stomach. A few additional sutures are inserted and the adjacent omentum is wrapped and stitched around the anastomosis. The incision in the diaphragm is closed with interrupted sutures up to the gap left for the passage of the stomach into the thorax. The stomach is firmly anchored to the edges of the gap by numerous linen-thread stitches. A stab incision is made in the tenth intercostal space in the mid-axillary line, and a rubber tube is inserted into the lower part of the pleural sac. The rib-spreader is removed, and the lung is gradually expanded by positive pressure. The wound in the chest wall is closed after sutures have been tied around the adjacent ribs. The lower lobe may fail to expand as a result of a plug of mucus in the bronchus, and arrangements should be made for this to be cleared, if necessary, by suction through an endoscope before the chest is closed. Even after several days the expansion of the lung can be successfully restored in co-operation with a laryngologist.

At least 1,000 c.c of blood are given during or immediately after the operation, and glucose and saline are continued intravenously for several days The drain is removed after three days, or sooner if drainage has ceased. If, later, there are signs of fluid in the pleural cavity, the fluid should be removed by aspiration.

After a satisfactory anastomosis the patient may be allowed sips of water within forty-eight hours of the operation.

J. M. G.

tube may be fashioned, however, from the greater curvature of the stomach and the open end sutured near the left costal margin. The best alternative, probably, is to use a free loop of jejunum, which is brought through the transverse mesocolon. Further access is obtained by opening the gastro-colic omentum from the front. The lower end of the loop is sutured to the posterior wall of the stomach, and the loop is then brought upwards in front of the stomach to the upper angle of the wound, where it is anchored to the parietal peritoneum and sutured at a higher level for end-to-end union to the skin tube.

Oesophagectomy for Carcinoma of the Lower Third of the Oesophagus—If the growth in the oesophagus extends to the level of the diaphragm, or if it has arisen in the cardiac end of the stomach, a laparotomy should be performed two weeks before the resection. This will allow an inspection to be made for glandular spread below the diaphragm, and will determine the operability of tumours of the cardia A jejunostomy can at the same time be performed, and this should be done, when necessary, in preference to a gastrostomy, which would interfere with the subsequent mobilization of the stomach.

The patient is placed on the right side, and a long incision is made in the seventh intercostal space The pleura is opened from the anterior end of the space and the lung is allowed to collapse partially. It may be necessary in older patients to divide the seventh and eighth ribs as far back as possible. The oesophagus is found between the pericardium in front and the aorta behind

If the growth is operable the phrenic nerve is crushed. Before the mediastinal pleura is opened some surgeons infiltrate the tissues around the oesophagus with 2 per cent. novocain in order to block the vagal plexus and to facilitate the dissection. During the resection both vagi are usually divided without any obvious ill effects. The oesophagus with the growth is isolated down to the hiatus. The dome of the diaphragm is now incised in a radial direction towards the hiatus into which the incision extends The fundus and cardiac end of the stomach are exposed, and the vessels in the lesser and greater omenta at the curvatures are secured and divided between ligatures. The spleen is readily pulled up into the thorax and may safely be removed if it is in the way The extent to which the stomach should be freed from its attachments will vary in the individual case. When the carcinoma is confined to the oesophagus, the stomach need be freed only to an extent sufficient to enable it to be brought up into the pleural cavity without tension to the level necessary for the anastomosis. When part of the stomach has to be removed the blood-supply will still be adequate if the pyloric and right gastro-

strong cutting forceps, such as Waggett's shears. In elderly subjects the cartilage is generally so ossified that a small nasal saw is required. The divided alae are held aside; a tag of mucosa may have to be divided before the interior of the larynx is revealed. When the removal of a portion of the cord is contemplated, the inside of the larynx is swabbed with cocaine and adrenaline to minimize surface bleeding. The inner perichondrium of the thyroid is then stripped

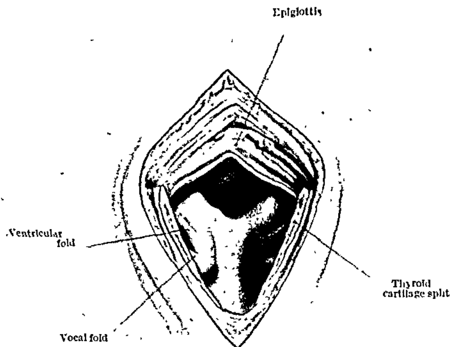


Fig. 121. Thyrotomy.

back and the whole neoplasm raised With curved scissors the tissues are cut through beyond the limits of the growth, and the posterior end of the vocal cord is divided, any bleeding-points being dealt with by gauze pressure. The divided halves of the thyroid cartilage fall into natural position and the perichondrium over them is stitched The skin incision is closed The tracheotomy tube can be removed in from twelve to twenty-four hours. When the neoplasm is limited to the anterior end of the cord, the thyroid cartilage *must* be carefully sawn through in the middle line without damaging the underlying perichondrium as this may have to be removed in one piece with the affected cord.

The growth is usually more extensive than appears on laryngo-

OPERATIONS ON THE AIR-PASSAGES

Laryngo-fissure or Thyrotomy. Laryngotomy. Tracheotomy. Laryngectomy.

Laryngo-fissure or Thyrotomy.—This operation consists in splitting the thyroid cartilage in the middle line to view the larynx in cases of stenosis and impacted foreign body, or to remove intrinsic malignant lesions without excising the entire larynx. In malignant

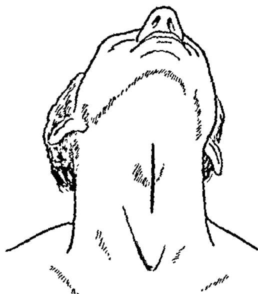


FIG. 120. Incision for Thyrotomy.

disease it is preferably confined to cases in which the middle third of one cord is affected, and the cord is still mobile.

The operation can be performed under local anaesthesia, but if a general anaesthetic is preferred it should be combined with local *infiltration, which checks bleeding and allows of a lighter level* of inhalation anaesthesia

With the patient's head extended, a median incision is carried from the hyoid bone to the sternal notch, dividing the skin and fascia. The front of the thyroid cartilage, the cricoid, and the trachea are laid bare, and the thyroid isthmus is split and held aside A median tracheotomy is performed through which the larynx can be packed, and the anaesthetic is continued through a tracheotomy tube. The thyroid cartilage is then split in the middle line with

(high tracheotomy) or below it (low tracheotomy). In practice the operation may not fall into one of these categories because it is often necessary to carry the incision through the thyroid isthmus; this plan should always be used in children when the operation is being done as an emergency, e g. in laryngeal diphtheria. Opening the tracheal cartilages through the third ring avoids the possibility of damage to the cricoid cartilage with the possible sequels of permanent impairment of speaking and of a tendency to stenosis.

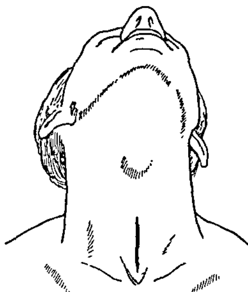


FIG. 122. Incision for Low Tracheotomy.

In adults the operation is best performed under local anaesthesia, in children, when the operation is usually for an acute emergency, local anaesthesia results in a drier field, and less tendency to increased secretion of mucus Chloroform is the best general anaesthetic for an emergency tracheotomy If time permits, the larynx should be lightly sprayed with a 5 per cent. solution of cocaine. The patient lies on his back in a good light (a child can be wrapped in a thin sheet to restrain the arms), a small sandbag is placed beneath the shoulders so that the neck is hyperextended, the occiput must rest on the table to prevent alteration of position. The skin and deeper tissues are infiltrated in the median line, about 30 c.c. of ½ *per cent.* novocain with 3 minims of adrenaline is usually sufficient. An incision 5 cm. (2 in.) long is made exactly in the midline, *from the* crico-thyroid interval to below the isthmus of the thyroid gland. Skin and fascia are divided, and the superficial veins are secured. The medial edges of the sternohyoid muscles are separated and

scopy. If this is so, it is best to perform a submucous resection of the thyroid cartilage on the affected side. This affords a more complete exposure of the neoplasm and better control of bleeding, and allows of complete removal of the growth with an ample margin.

Fenestration of the Thyroid Ala for Insertion of Radium.—In radium therapy of malignant disease of the larynx radium needles are inserted against the inner perichondrium and left in position for a period which depends upon the dosage required. Radium treatment gives better functional results than removal of a vocal cord.

The operation can be performed under local anaesthesia. The ala of the thyroid is exposed through a shorter median incision than that used in thyrotomy, or through a collar incision over the lower border of the thyroid cartilage. The perichondrium over the thyroid cartilage on the affected side is elevated, and a small hole is made through the cartilage, care being taken to preserve the inner perichondrium. This hole is enlarged till only a sufficient rim of the cartilage of the ala is left to hold the needles in position.

Usually six needles are used: two containing 2 mg. of radium each, and four containing 1 mg. each. The 1-mg. needles are threaded on silk and placed vertically over the perichondrium like the bars of a window: one of the 2-mg. needles is placed horizontally along the bottom of the window, and the other along the top. The threads attached to the needles are brought out through the wound or they may temporarily be buried under the skin. The wound is closed, with a small silk drain to the surface. Four or five days later, depending on the required dosage, the needles are removed by pulling upon the threads.

Laryngotomy.—This operation, which consists in opening the larynx by dividing the cricothyroid membrane, is performed in emergency for threatened suffocation, and as a preliminary in operations on the jaws, pharynx, or tongue.

A horizontal incision is made over the cricothyroid membrane, the deep fascia is divided in the median line, and the sterno-thyroid muscles are drawn aside. The thyroid and cricoid cartilages are then defined, and the membrane is incised transversely, the knife being inserted close to the upper border of the cricoid cartilage, to avoid injuring the cricothyroid arteries. The incision must not be extended so far laterally as to injure the cricothyroid muscle. The tube, which should be oval in its transverse axis, is then inserted. In children the cricothyroid space may not afford sufficient room, and it may be necessary to divide the cricoid cartilage.

Tracheotomy.—The purpose of the operation is to relieve dyspnoea and to prevent asphyxia by admitting air into the trachea. The trachea may be opened above the isthmus of the thyroid gland

of cocaine has not prevented coughing, the operator waits until respiration is calmer before putting the tube in the trachea. It is important not to damage the tracheal rings. The tube is secured by tapes round the neck, and the skin edges beyond the tube are brought together with stitches.

After emergency operations for the relief of temporary dyspnoea, the tracheotomy tube should be discarded as soon as the patient can breathe through the natural channels.

When tracheotomy is performed as a preliminary to pharyngotomy or laryngectomy, the operation below the isthmus is to be preferred, and it is best done some days before the more important operation. The low operation may be called for also in the removal of foreign bodies which have become impacted low down in the trachea or in one of the bronchi.

The incision is made between the cricoid cartilage and the episternal notch, and the dissection is carried out on the same lines as in the high operation. In addition to various cross branches of veins, the inferior thyroid veins are found in front of the trachea, and in exceptional cases the thyroidea ima artery. In the child, the innominate artery may project above the jugular notch, and the remains of the thymus gland may be found in front of the trachea.

The low operation is more difficult than the high one, as there are more veins to be secured, and, since the trachea lies farther from the surface, a longer tube must be used.

In elderly persons the rings of the trachea may be calcified or ossified and refuse to yield to the knife. The air-passage should then be incised between two rings of the trachea, and one blade of a strong pair of scissors inserted into the passage to divide the rings

Total Laryngectomy.—Excision of the larynx is indicated in cases of malignant disease when the growth is too extensive for treatment by thyrotomy by the insertion of radium. Early secondary involvement of the cervical lymph glands does not contra-indicate its performance, infected glands situated on the left side being excised at the original operation; when they are on the right side, it is preferable that they be removed at a subsequent operation.

The operation is performed under intratracheal anaesthesia. A preliminary tracheotomy is not only unnecessary, but it renders the operation more difficult and increases the risk of infection of the lungs by the entrance of secretions from the wound into the air-passages.

The patient is placed in the dorsal position with the head extended and turned to the right side. A J-shaped incision is made extending from the angle of the jaw downwards in front of the *anterior margin*

drawn aside; an equal strain must be kept on both muscles and the position of the tracheal cartilages must be verified with the finger, otherwise direction may be lost. The cellular tissue in front of the trachea is cleared. The deep fascia from the thyroid isthmus over the front of the trachea is now exposed; it is detached from the lower border of the cricoid cartilage. In children the isthmus of the thyroid gland should be divided between ligatures in the median

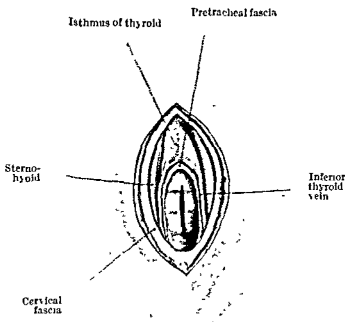
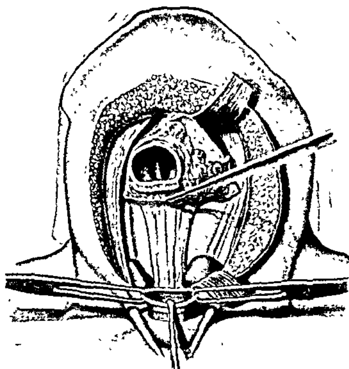


FIG. 123 Low Tracheotomy.

line, the tracheal rings are then exposed All active bleeding is arrested About 3 drops of a 5 per cent solution of cocaine are injected through a fine hypodermic needle into the lumen of the trachea The larynx is steadied, either with a sharp hook engaging the lower border of the cricoid cartilage, or by slight upward traction on the thyroid cartilage One or two rings, preferably the third and second, are then incised from below upwards The cut edges of the tracheal wound are seized with small-toothed dissecting forceps and a small portion is removed from each edge with curved scissors, to make a slightly oval window in the trachea and to lessen any risk of tearing when the tracheotomy tube is introduced through the opening. This window relieves the dyspnoea, and as the intratracheal injection of *cocaine should have prevented coughing, the tracheotomy* tube can be introduced quietly and deliberately. If the introduction

into the pharynx. The great cornu of the thyroid cartilage is divided with cutting forceps. The right sternohyoid muscle is retracted laterally; the right sterno-thyroid and thyro-hyoid muscles are cut through, and the right great cornu cut with forceps.

A transverse incision 2·5 cm. (1 in.) long is now made through the skin above the manubrium sterni below the curved incision.



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Fig. 125. Total Laryngectomy. Trachea divided—Dissection of Larynx from Pharynx.

The trachea is divided across at the level of the first tracheal ring. The intratracheal catheter is now removed, and the trachea is drawn through the opening in the skin so that it projects beyond the surface, and is fixed with silk sutures. A tracheotomy tube is inserted and a soft catheter introduced for continuation of the intratracheal insufflation

The upper end of the divided trachea is now hooked forwards and dissected upwards from the pharynx, dividing the constrictor muscles (Fig 125) The pharynx is opened into at the posterior margin of the glottis, and a finger introduced and the extent of the growth examined If the epiglottis is not involved, the pharynx is opened into above by dividing the base of the epiglottis, and the larynx is removed. A transverse slit is thus left opening into the pharynx,

of the left sterno-mastoid to a point 5 cm. (2 in) above the sternum. Here it curves forwards and medially and terminates at the anterior margin of the right sterno-mastoid at the same level. This flap, including the platysma muscle, is dissected upwards, and the left anterior jugular vein is exposed. It is dissected free, ligated above and below, and excised. The margin of the left sterno-mastoid

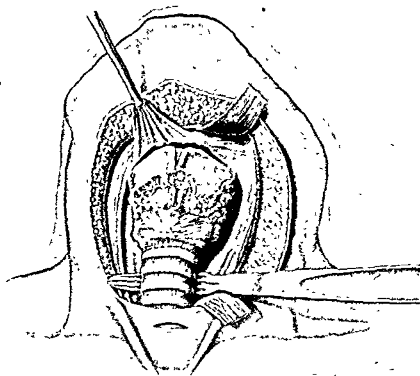


FIG 124. Total Laryngectomy. Mobilization of Trachea and Larynx.

is then defined and the muscle is mobilized and retracted laterally. The superior thyroid artery is ligated and divided, and the left omohyoid muscle is divided The left sternohyoid and sterno-thyroid muscles are mobilized and divided at their upper ends and folded down. The isthmus of the thyroid gland is now divided and the lateral lobes separated off the trachea and displaced laterally. The cleft between the oesophagus and trachea is defined and the fascia uniting them severed. A dissector is introduced, separating the trachea and the oesophagus at the upper end. The left thyro-hyoid muscle is then divided and the upper margin of the thyroid cartilage bared and the mucous membrane of the pharynx separated from it without opening

into the pharynx. The great cornu of the thyroid cartilage is divided with cutting forceps. The right sternohyoid muscle is retracted laterally; the right sterno-thyroid and thyro-hyoid muscles are cut through, and the right great cornu cut with forceps.

A transverse incision 2·5 cm. (1 in.) long is now made through the skin above the manubrium sterni below the curved incision.

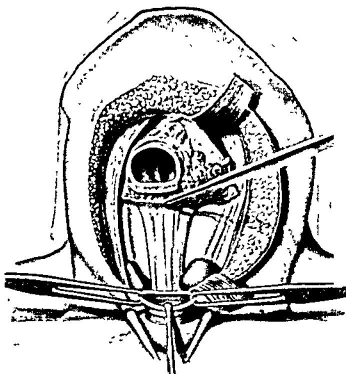


Fig. 125. Total Laryngectomy. Trachea divided—Dissection of Larynx from Pharynx.

The trachea is divided across at the level of the first tracheal ring The intratracheal catheter is now removed, and the trachea is drawn through the opening in the skin so that it projects beyond the surface, and is fixed with silk sutures. A tracheotomy tube is inserted and a soft catheter introduced for continuation of the intratracheal insufflation.

The upper end of the divided trachea is now hooked forwards and dissected upwards from the pharynx, dividing the constrictor muscles (Fig. 125). The pharynx is opened into at the posterior margin of the glottis, and a finger introduced and the extent of the growth examined. If the epiglottis is not involved, the pharynx is opened into above by dividing the base of the epiglottis, and the larynx is removed A transverse slit is thus left opening into the pharynx.

This is tightly closed by a continuous suture of chromicized catgut (Fig. 126).

If the epiglottis has to be removed, the wound of the pharynx is left open. If the lateral wall of the pharynx is involved, a partial pharyngectomy may be performed, and if so an effort should be made to conserve a vertical strip of the mucous membrane of the

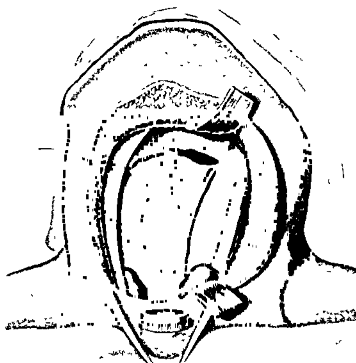


FIG. 126. Total Laryngectomy. Closure of Pharynx.

pharynx on its posterior wall, as from this the pharynx may be reconstituted

The lobes of the thyroid gland are now displaced downwards on to the upper and lateral surface of the trachea, and the divided sternohyoid and sterno-thyroid muscles placed so as to fill the cavity at the lower end of the wound. The wound is now sutured at its lower curved portion and at its upper end. The middle of the wound is left open and packed (Fig. 127) *If the wound of the pharynx has* been left open, an oesophageal tube is inserted into the stomach. If it has been closed, the patient is fed for ten days by a stomach tube inserted through the mouth at each meal. In the majority of cases when the pharynx has been closed, primary union of the pharyngeal wound takes place In others it breaks down in part, forming a temporary pharyngeal fistula in the neck, as occurs when the

pharyngeal wound is left open. In either case this subsequently closes. Ultimately the patient can make himself faintly audible in a whispering voice. An artificial larynx can be obtained which enables him to talk loudly and articulate more clearly.

An alternative incision aims at constructing a flap with its base upwards, its apex at about the level of the first tracheal ring, and

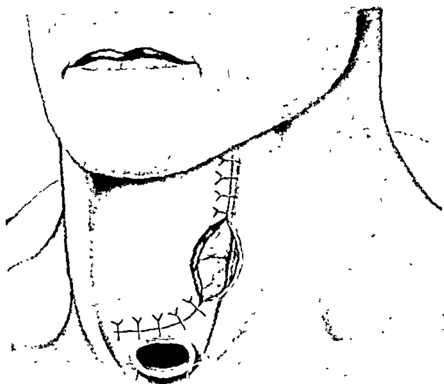


FIG. 127. Total Laryngectomy. Permanent Tracheotomy Wound partly closed and packed.

with the converging lateral margins so designed as to make the apex more narrow than the base This tends to prevent breaking down of the reconstructed pharynx In cases where a previous laryngo-fissure has been performed, an I-shaped incision is used, the median part of which follows the incision for the laryngo-fissure, ending in two collar incisions, the lower over the area chosen for the tracheotomy tube, the upper over the hyoid bone.

Another operation has been suggested in cases in which there is an intrinsic carcinoma of the larynx too extensive for laryngo-fissure, but no metastatic extension. The operation can be performed under local anaesthesia A midline incision is employed, as for

laryngo-fissure (skin flaps are not dissected back). The sterno-thyroid and thyro-hyoid muscles are detached from the thyroid cartilage. After retraction of the whole of the larynx to each side in turn, the superior and inferior laryngeal arteries are exposed and ligated; the cornu of the thyroid on each side is clipped through and left in position, or dissected out later. The pharynx is opened above, the epiglottis grasped, and the whole larynx brought forward. The pharyngeal wall is exposed and stripped backwards, leaving the tissue as loose as possible to aid the closure of the pharynx. The pharynx can be closed in the form of an inverted 'V', some fibres of the inferior constrictor, sterno-thyroid, and thyro-hyoid muscles being used for additional support. The trachea is then cut across and the lower part anchored to the skin. The skin edges are brought together. A small drainage tube may be brought through a lateral incision.

G. E. M.

CHAPTER XIX

OPERATIONS ON THE CHEST

Anatomy. Anaesthesia. Bronchoscopy. Chest Wall. Empyema. Lung Abscess. Thoracotomy. Pneumonectomy and Lobectomy. Pulmonary Tuberculosis. Heart. Diaphragm. Injuries.

Anatomy.—The upper edge of the *sternum* is opposite and about 6.5 cm. (2½ in.) from the fibro-cartilage between the second and third thoracic vertebrae. The manubrium joins the body of the sternum at a slight angle (sternal angle) marked by a transverse ridge at the level of the second costal cartilage. The xiphi-sternal junction is opposite the ninth thoracic vertebra.

The *spines* of the thoracic vertebrae incline downwards so that their tips are at a lower level than the corresponding bodies. In the upper and lower vertebrae the spine is opposite the upper part of the body of the vertebra next below; in the middle vertebrae it is opposite the lower part. The spine of the *first* thoracic vertebra is the lower of the two prominences at the root of the neck When the scapula is in the position of rest, the spine of the *third* is opposite the root of the spine of the scapula; the spine of the *seventh* is opposite its inferior angle. The spine of the *twelfth* is opposite a point midway between the inferior angle of the scapula and the iliac crest.

The most accurate method of identifying *ribs* is to locate the *second* from its cartilage, and count from it. The scapula overlies the second to the seventh ribs; the fourth rib lies deep to the medial end of the scapular spine; the eighth lies just below the inferior angle of the scapula. The twelfth rib can often be felt at the lateral margin of the sacro-spinalis.

Behind the angles of the ribs, the *intercostal artery and nerve* cross the intercostal space obliquely and are liable to be injured in aspiration or incision of the chest In front of the angles, they lie in the costal groove, and are safe from injury if incisions and exploratory punctures are made close to the upper margin of the rib The intercostal artery in each space lies below its companion vein and above the nerve; it is at first between the posterior intercostal membrane and the pleura, and then between the two intercostal muscles

The internal mammary vessels lie about 1 25 cm (½ in) lateral to the edge of the sternum The left innominate vein and the branches of the aortic arch

The *phrenic nerve* springs from the anterior ramus of the fourth cervical nerve and receives also small contributions from the third and fifth, and sometimes from the sixth It begins at the lateral border of the scalenus anterior at the level of the upper border of the thyroid cartilage, and descends over the front of the muscle, crossing it from lateral to medial border under cover of its fascia At the root of the neck it lies on the pleura behind the innominate vein It enters the thorax opposite the first costal cartilage and descends along the sides of the great vessels and the pericardium to the diaphragm. The root from the fifth nerve springs occasionally from the nerve to the subclavius; and in some cases it descends independently into the thorax and joins the main phrenic trunk at a varying point between the root of the neck and the root of the lung

In the erect posture, the apex of the *lung* extends for a distance of about 2 5

cm (1 in.) above the medial third of the clavicle A line drawn from the xiphi-sternal joint towards the last thoracic spine indicates the lower reflection of the

upper, middle, and lower. Each fissure reaches almost to the hilum, so that the lobes are almost completely separate from each other. The oblique fissure is opposite a line which begins a finger's-breadth lateral to the second thoracic spine, and is drawn obliquely round the thoracic wall to end at the sixth costal cartilage about three finger-breadths from the median plane, 2 5 cm. (1 in.) or more below the level of the xiphi-sternal joint. Owing to the oblique direction of the fissure, the portion exposed when the thorax is explored at the back or at the side is the lower lobe The transverse fissure of the right lung is opposite a line which begins at the middle of the sternum at the level of the fourth cartilage, and is drawn to the right to the mid-axillary line.

Anaesthesia

The chief considerations governing the choice of anaesthetic method for a thoracic operation are open pneumothorax and bronchial obstruction by pus and mucus.

When a pleural space free from adhesions is opened, the lung within it shrinks towards the hilum and the mediastinum moves towards the opposite side. With expiration the mediastinum returns to the midline and air is expelled from the lung of the intact side, some by the trachea and some into the collapsed lung. Inspiration draws the mediastinum again away from the open side and the diminished amount of air which enters the lung of the intact side is partly fresh (from the trachea) and partly used (from the collapsed lung). This mediastinal 'flutter' and paradoxical movement of the collapsed lung greatly impair both oxygenation and circulation of the blood. In emergency the ill effects of open pneumothorax may be reduced by traction on the collapsed lung to steady the mediastinum, but in a planned operation they are eliminated by the administration of oxygen at a controlled pressure and rate of flow through an air-tight face mask or endotracheal tube. This is best combined with general inhalation anaesthesia

In pulmonary operations under general anaesthesia provision must be made against asphyxia from the flow of pus from diseased bronchi. The simplest precaution is to incline the table so that bronchial secretions will run into the pharynx It is an additional safeguard if the contents of the bronchi can be aspirated, as occasion arises, by the passage of a gum-elastic catheter along a wide endotracheal tube Other methods are available for the protection of the healthy lung from the entry of pus The anaesthetic may be delivered directly into the healthy main bronchus through a tube made to fit the bronchus with air-tight accuracy by the attachment of an inflatable cuff at its

distal end. This tube is carried on a special bronchoscope for its introduction. Alternatively the diseased main bronchus may be drained by the introduction into it of a slender tube similarly fitted to the bronchus by an inflatable cuff, and with its other end outside the patient's mouth. The tube can be introduced through an unmodified diagnostic bronchoscope, and leaves enough space in the trachea for administration of the anaesthetic, either by endotracheal tube or by face mask. The shortness of the right main bronchus sometimes causes difficulty in the adjustment of endobronchial tubes on that side.

Cyclopropane and ether are the anaesthetic agents commonly used. Cyclopropane is preferred because of its less irritant effect on the bronchial mucosa and its more rapid excretion. Either drug gives quiet anaesthesia when administered by a closed method with efficient carbon dioxide absorption and good oxygenation. Both are explosive, and during their administration the use of diathermy or the cautery on the lung and inside the pleural space should be avoided.

In general anaesthesia the control of endobronchial pressure permits inflation of the lung during operation to demonstrate segmental collapse, or to ensure that the lung or its remaining lobe more nearly fills the pleural space at the time of closure of the pleura. Respiratory movement can be controlled by the anaesthetist, and even temporarily suspended. The respiratory centre is first depressed with morphine or thiopentone sodium; then by pressure on the rebreathing bag to increase the depth of inspiration, carbon dioxide is washed out of the alveoli until its concentration is so low that it ceases to be an adequate stimulus to respiration Thereafter the only respiratory movement is the expansion of the lungs in response to pressure by the anaesthetist on the rebreathing bag.

The presence of ribs as a palpable mark of depth and an accurate guide to the position of the intercostal nerves makes local analgesia of the normal chest wall both simple and reliable. It is less satisfactory when deformity of the posterior ends of the ribs or a lesion overlying the rib angles and sacrospinalis muscle prevents easy access to the nerves, and when extrapleural fibrosis delays spread of the injected fluid. It has the advantage of preserving the cough reflex.

Infiltration of the skin and superficial muscles with a solution of procaine 0·5 per cent to each 30 c c (1 fl oz) to which one drop of 1/1000 adrenaline solution has been added, together with nerve block of the intercostal nerve in each space to be incised, or above and below each rib to be resected, with a solution of procaine 2·0 per cent with adrenaline, gives analgesia for approximately one hour. Somewhat longer duration of analgesia is given by 0·5 per cent. procaine

with 0·06 per cent. pantocaine for both infiltration and nerve block. An intercostal nerve is conveniently reached where it lies in the costal groove from the angle of the rib to the costochondral junction. When analgesia posterior to the angle is required, the nerve block is made near the intervertebral foramen, from which the nerve crosses the intercostal space obliquely to reach the costal groove.

Without induction of analgesia other than that of the chest wall, extensive intrathoracic operations can be performed provided that a free pleural space is not opened.

Bronchoscopy

Removal of foreign bodies in the trachea and bronchi, excision of certain non-malignant growths, aspiration of secretions too tenacious to be ejected by coughing, and local medication of the bronchial walls can be performed through the bronchoscope. Bronchoscopy is important in the diagnosis of bronchial neoplasms; less than 20 per cent. of these occur outside the bronchoscopic field. Exclusion by bronchoscopy of bronchial neoplasm, granuloma, and foreign body is a necessary step in the investigation of unexplained cough, haemoptysis, pulmonary collapse, pulmonary abscess, bronchiectasis, empyema, and pneumonia which is atypical, unresolved, or recurrent. Some help in estimating the position and extent of disease in the peripheral part of the lung may be obtained from observing which bronchial orifice is the source of pus, blood, or excess mucus. When an abnormality is discovered, a specimen of secretion or tissue may be taken for bacteriological or histological examination. The only contra-indication to bronchoscopy is aneurysm of the thoracic aorta.

General anaesthesia is necessary in children, but for adults local anaesthesia is satisfactory A hypodermic injection of omnopon gr. $\frac{1}{3}$, with hyoscine gr. 1/150 is given one hour previously. The surface anaesthetic used is 5 per cent cocaine hydrochloride in water, with a maximum dose of 7 c c (2 fl dr) to which 5 drops of adrenaline 1/1000 have been added The mouth and pharynx are sprayed from an atomizer during deep respiration A wet cotton-wool pledget is held with curved forceps for a minute in each pyriform fossa. The glottis is then inspected through a direct laryngoscope, and 1 c c. of the local anaesthetic is injected into the trachea through a long cannula between the vocal cords At the end of the short fit of coughing which follows the patient is ready for bronchoscopy

For the introduction of the bronchoscope the patient lies on his back with neck flexed and head extended A pillow under the neck adequately maintains this position The bronchoscope is introduced with the light-carrier towards the tongue, nearly as far as the posterior pharyngeal wall, then directed distally in the pharynx until the

epiglottis is seen. This is lifted anteriorly on the tip of the bronchoscope and the aperture of the larynx is exposed. The bronchoscope can be slipped into the trachea while the cords are separated in inspiration, and advanced as far as the main carina. The tracheal wall is pink and glistens with a thin layer of mucus. Anteriorly and on the sides the outlines of the cartilages can be seen, and the posterior wall bulges slightly into the lumen of the bronchoscope. The carina is sharp and paler in colour than the mucosa elsewhere. With the head flexed towards the left the bronchoscope can be passed into the right bronchus. The bronchial walls are similar to those of the trachea except that the outline of the cartilages is less clearly visible. The orifice and first few millimetres of each branch of the stem bronchus can be inspected. The bronchus of the upper lobe arises from the lateral wall just below the level of the main carina, 2·5 cm. (1 in.) distally, from the anterior wall arises the middle lobe bronchus; and from the posterior wall, the dorsal branch; then in close succession the cardiac branch from the medial wall, the anterior basal from the antero-lateral wall, and finally the bifurcation into axillary and posterior basal branches. During examination of the left bronchus greater flexion of the head to the opposite side is required. Aortic pulsation is strongly transmitted along the bronchoscope The main bronchus is 6·25 cm. (2½ in.) long and the upper lobe bronchial orifice twice as large as that on the right. The lingular branch, corresponding to the middle lobe bronchus on the right, arises from the upper lobe bronchus. There is no cardiac branch. Otherwise the two sides are bronchoscopically similar

Telescopes may be used to give a magnified image of the mucosa, and with 90° vision, to show a greater length of both upper lobe bronchi. All manipulations, including withdrawal of the bronchoscope, are visually controlled and care is taken to avoid pressure on the upper lip, teeth, or gum. For two hours after bronchoscopy, to prevent burning or inhalation of foreign material, nothing is given by mouth.

Operations on the Chest Wall

Rib Resection.—Short posterior segments of the highest three ribs can be exposed through a vertical incision cutting across or splitting the trapezius and rhomboid muscles between the scapula and the vertebral column. For their wider exposure the incision must be prolonged round the inferior angle of the scapula and the superficial muscles divided in the same line to allow reflexion of the scapula upwards and laterally Their anterior and axillary portions are exposed by an incision splitting the pectoralis major muscle in the line of its fibres The fourth and lower ribs are exposed through

an incision parallel to and overlying the part for resection. In female patients a curved incision reflecting the breast upwards and medially may be required for exposure of the anterior ends of the third, fourth, and fifth ribs

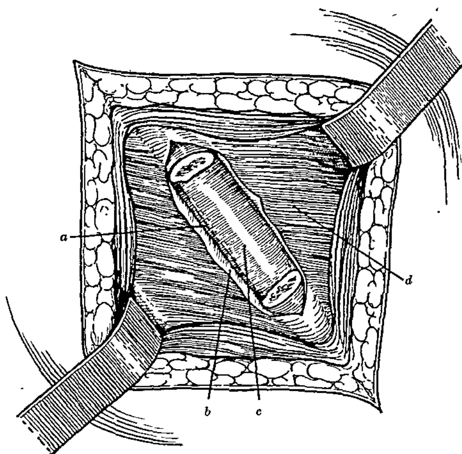


FIG. 128 Drainage of Pleura with Rib Resection.

(a) Intercostal vessels and nerve
(b) Periosteum from outer surface of rib
(c) Periosteum of deep surface of rib.
(d) External intercostal muscle.

The periosteum is incised longitudinally and stripped from the outer surface of the rib. To clear the upper border, the action of the raspatory is from behind forward, and to clear the lower border from before backward, according to the angle of attachment of the external intercostal muscle. The vessels in the costal groove are easily avoided if the edge of the raspatory is kept close to the bone. Periosteum and [illegible] curved raspatory. [illegible] with shears, and is then removed [illegible].

A similar procedure is used for resection of costal cartilage. Peri-

chondrium is separated with less ease than periosteum because of its greater toughness and the tendency of the raspatory to cut into cartilage.

Ligation of Intercostal Vessels.—Resection of 3 cm. (1¼ in.) of rib is required for the exposure of the vessels. The nerve which lies below them is carefully separated before application of the ligature. Because of free anastomosis with the internal mammary arteries, the vessels must be tied both anterior and posterior to the bleeding-point.

It is possible to occlude intercostal vessels with a stout suture carried round an intact rib and firmly tied, but this necessarily damages pleura and is likely to include also the intercostal nerve.

Ligation of Internal Mammary Vessels.—Resection of 3 cm. (1¼ in.) of costal cartilage close to the sternum, and incision of the posterior perichondrium gives adequate access.

Operation for Osteitis of Ribs.—Pyogenic osteitis is infrequent except as a complication of wounds of the chest wall. Tuberculous osteitis occurs most often at the costochondral junction. A focus of pyogenic or tuberculous infection in rib or cartilage may be removed by resection of the diseased segment. In the case of rib it is enough to divide the bone just beyond the limits of the disease Partial resection of a cartilage is likely to be followed by persistence of the infection. It is advisable, therefore, to remove the entire cartilage, or if there is disease in the sixth cartilage or lower, the block of fused cartilages. If skin sinuses are present they are curetted or excised at the same operation. It is sometimes possible to remove a small encapsulated cold abscess along with the diseased bone. The rib is divided subperiosteally anterior and posterior to the abscess, and the intercostal vessels are tied. The diseased rib, together with its abscess, is then dissected out and removed. The underlying pleura is thickened, but care must be taken not to incise it.

Operation for Tumours of the Ribs.—Sarcoma is the commonest primary tumour of ribs At the time of its diagnosis it usually involves several ribs and the soft tissues between them, and may have spread towards both pleura and skin.

The extent of the growth is ascertained with the help of radiography, diagnostic pneumothorax, and thoracoscopy. Its removal entails wide opening of the pleural cavity; therefore general anaesthesia with control of endotracheal pressure is used.

If the skin is invaded, the incision encircles the tumour Otherwise a wide U-shaped flap of skin and superficial muscles is turned up to expose it. The ribs to which the tumour is attached are divided subperiosteally well beyond its limits, and the intercostal vessels are tied at the same points. The pleura and the intercostal tissues are then divided round the tumour, and it is removed.

The defect in the chest wall may be closed by mobilizing the pectoralis major or latissimus dorsi muscles, or, in women, with the breast. If the defect is low on the chest wall, the diaphragm may be sutured to its margins. *The lung is inflated just before completion* of the closure.

A pleural effusion usually occurs after operation, and this requires aspiration.

If the tumour is extensive or the patient debilitated, the operation may be performed in two stages, the first (up to the ligation of the intercostal vessels) under local analgesia.

Operations for Acute Empyema

The aim of operation in acute empyema is to empty the empyema cavity and to promote re-expansion of the lung. The associated reduction in vital capacity and the risk of flooding the bronchi with pus make it advisable to use local rather than general anaesthesia

Acute empyema usually begins as a sequel to a localized subpleural infection, and is at first confined to a part of the pleural space Conversion of this partial empyema to a total empyema and further embarrassment of respiration by an open pneumothorax are important causes of delay in recovery and of death. These consequences *are to be avoided by the use of a method of drainage which does* not permit free entry of air into the pleural space before the lung is fixed to the chest wall by adhesions round the empyema There is no direct method of ascertaining when this has occurred, but the consistence of *fluid obtained by pleural paracentesis is taken as a guide If the pus* is thin and watery it must be deduced that the formation of adhesions is still inadequate to keep the lung expanded, and that the mediastinum is still mobile Pus of a creamy consistence is an indication that the empyema is encysted, and that wide opening of the pleura is not only safe but desirable

Mechanical disturbance of respiration may make a patient so ill that although thick pus is present a minor drainage operation must be used as an initial procedure, and free drainage delayed until the patient's condition has improved These circumstances occur particularly in young children.

Paracentesis.—Paracentesis of the pleura is necessary in the diagnosis of every empyema to confirm the presence of pus and to ascertain the nature of the infecting organism. It is preceded by accurate localization of the suspected pus both clinically and radiologically. In the common postero-inferior empyema the site of paracentesis should rarely be lower than the ninth interspace, in the line of the rib angles, because in the costophrenic sinus the pleural

space is at best narrow, and it may be obliterated by adhesions or filled with fibrinous clot.

The patient sits erect and is supported to enable him to do so without exhaustion. An interspace overlying the empyema is chosen, and with 5 c.c. of 2·0 per cent. procaine a cutaneous wheal is raised, and the soft tissues of the chest wall are infiltrated along a track passing just above the upper border of a rib to avoid damage to intercostal vessels. No further injection is made after the needle has penetrated the pleura, to avoid spreading infected fluid in the chest wall. A fresh syringe and needle are then used to aspirate a specimen of pus.

Removal of most of the pus from an empyema daily or every second day will tide a patient over until he is well enough for rib resection, or until the empyema becomes encysted. In some cases it is possible to secure healing by repeated aspiration combined with general and local chemotherapy. The most satisfactory apparatus for withdrawal of large quantities of pus is a 20-c.c. syringe carrying a two-way tap and a wide-bore 3-inch needle, each held in position by a bayonet catch.

Intercostal Drainage.—Intercostal drainage is indicated in non-encysted empyema and in patients too ill for rib resection. It causes less disturbance to the patient than repeated aspiration, and permits similar control of the flow of pus and exclusion of air from the pleura. It is always preceded by aspiration, and performed at a site under which an empyema cavity more than 3 cm. (1¼ in.) deep has been felt with the needle, so that there can be no risk of injury to the diaphragm or to the lung. No additional anaesthesia is necessary. An incision 1 cm. (½ in.) long is made through the skin. A trocar with its cannula of as large a size as will easily pass between the ribs is thrust through the superficial and intercostal muscles until it just enters the empyema cavity. The trocar is withdrawn and a Malecot catheter fitting the cannula, lubricated externally, and stretched on a lubricated stilette, is passed along the cannula until its end enters the cavity. With the catheter held in position the cannula is removed so that the soft tissues of the chest wall grasp the catheter. Then the stilette is withdrawn. At any time when air might be admitted along the cannula or catheter, finger pressure must be used to exclude it. The drainage catheter is finally attached to a water-seal. This in its most convenient form consists of a large wide-necked bottle fitted with a two-hole stopper and filled to one-quarter with water. A glass tube 0·7 cm. (¼ in.) in diameter passes through the stopper to dip below the surface of the water; this is attached by its upper end by 90 cm. (3 ft.) of rubber tubing to the intercostal catheter. The respiratory fluctuation of water in the tube is an index of patency of the drain.

Intercostal drainage is in most cases inadequate to allow healing of an empyema. The narrow tube is easily obstructed by sloughs and fibrinous clots. Ten to fourteen days after intercostal drainage a mild superficial osteitis occurs in the rib above, which may be associated with local pain and pain in the distribution of the corresponding intercostal nerve. A week after intercostal drainage the empyema cavity is reduced in size and the lung is firmly adherent to the chest wall

Drainage with Rib Resection.—Drainage with rib resection is used to follow intercostal drainage when that has become unsatisfactory, or as the primary drainage in encysted empyema not associated with severe illness

If an intercostal drain has been well placed, the segment of rib above the drainage track should be resected, in the postero-inferior empyema, usually the ninth rib at the angle. A large empyema in healing tends to become dumb-bell shaped with an isthmus at the posterior axillary line, making a posterior and an axillary loculus. The axillary loculus is shallower, and drainage there is apt to leave an undrained posterior cavity. Resection of rib at the angle gives direct entry to the deepest part of the empyema and may avoid a secondary drainage The oedematous periosteum and pleura are incised in the middle of the rib bed, and the empyema emptied by the use of a suction pump The pleural incision is lengthened as far as the cut ends of the rib, and the interior of the cavity is inspected with illumination from a light on a malleable handle. Fibrinous clots and non-adherent sloughs are removed with the sucker, or with sponge-holding forceps. A piece of parietal pleura is excised for microscopic examination. A tube 1 25 c [illegible]
projects into the cavity to [illegible]
may be necessary to resect [illegible]
good when the patient is semi-recumbent The superficial muscles and skin are loosely closed round the tube and its outer end attached to a water-seal to receive the purulent discharge, and to provide a small negative pressure within the cavity.

From the first post-operative day attention must be given to the recovery of arm and respiratory movement, and to the prevention of scoliosis. The patient should be encouraged to walk as soon as his general condition is good enough When the quantity of discharge is less than 90 c c (3 fl. oz) in the day, the tube may be cut short and allowed to drain into the dressing. The drainage tube requires daily attention to verify that it is patent, and that it keeps the cavity empty. Change in the shape of the cavity during healing may call for drainage at a different site X-ray examination after the instillation of lipiodol into the cavity is used to estimate progress The tube

is finally removed when the pleural space is obliterated and only a track through the chest wall remains.

During convalescence a thorough investigation of the cause of the empyema must be undertaken. Suppuration in the mediastinum, chest wall, or subphrenic space must be considered. The pleura removed at operation, the sputum, and the discharge from the sinus are bacteriologically examined for tuberculosis and actinomycosis. Bronchoscopic examination is made for foreign body, stricture granuloma, and neoplasm in the large bronchi. Bronchography with lipiodol is used to exclude bronchiectasis. If any of these diseases underlies the empyema, drainage will either fail or give only temporary and insecure healing.

Operations for Chronic Empyema

When the treatment of chronic empyema is being considered the extent to which the patient's condition has deteriorated as a result of long-continued suppuration must be taken into account. Amyloid disease may limit the extent of operation. Anaemia may require correction by blood transfusion.

Operations for chronic empyema are best done under general anaesthesia. Crowding of the ribs and deposition of new bone on their inner surfaces makes nerve block less accurate and increases the difficulty of resection. If the bacterial flora of the empyema includes a sensitive organism, appropriate chemotherapy is used before and after operation. Removal of pleura for microscopy and complete inspection of the interior of the cavity for foreign bodies are invariably part of the operative procedure.

After exclusion of all cases of chronic empyema with a persistent primary lesion three groups remain:—

1. Those which are drained by a bronchus only or by an inadequate sinus in the chest wall.
2. Those in which drainage through the chest wall is adequate, but, as a result of ill-judged initial drainage, or the presence of a large broncho-pleural fistula, the empyema cavity remains large and expansion of the lung is prevented by a rind of organized deposit covering the visceral pleura.
3. Those in which drainage through the chest wall is adequate, but a small cavity with or without a broncho-pleural fistula remains, which shows no progressive diminution.

In the first group provision of external drainage may be enough to permit healing. Because of crowding of the ribs, resection of at least two is necessary to make an opening through which the boundaries of the cavity can be seen, and a wide drainage tube can be

introduced. Before operation the size and position of the cavity mu be accurately ascertained by X-ray, if necessary after the introdu tion of lipiodol.

In the second group the aim of operation is to remove the tiss which covers the visceral pleura and prevents re-expansion of tl lung. Access is by resection of the largest rib segment overlying tl cavity combined with division of the posterior ends of one or mo ribs above and below, and ligation of their intercostal vessels. Tl fibrous sheath covering the lung is incised and a plane of cleava found between it and the visceral pleura. The plane in some cases well defined and almost avascular, and the rind can be removed as sheet. In other cases the plane is indistinct, and removal of tl superficial layer is difficult and associated with much bleeding. I still others a plane cannot be demonstrated, and the removal fragments of tissue causes such pulmonary damage that the oper tion must be abandoned When it is possible, the whole viscer layer is removed, especially over the upper part of the lung. N attempt is made to remove the parietal layer. When decorticatio is complete, the lung can be inflated until it more nearly fills tl pleural space. After operation drainage to a water-seal is necessar

In those cases in which decortication has been abandoned or ha failed, extrapleural thoracoplasty, as for pulmonary tuberculosi will help to close the empyema cavity.

It is to the third group that the operation of 'decostalization' applicable. The ribs forming the external wall of the empyema ar exposed through an incision which runs upwards from the drainag sinus in the long axis of the cavity. Each segment of rib overlyin the cavity is resected, the corresponding intercostal vessels ligatec and the intercostal tissues, pleura, and fibrous sheet forming th outer wall of the cavity completely removed. The wound is lightl packed and left to heal by granulation and fibrosis. The time re quired for healing may be reduced by filling the cavity with a pedicle muscle graft from the latissimus dorsi or sacrospinalis muscle, an by closing the superficial tissues of the chest wall over it.

In some cases, as a result of destruction of lung tissue, one or mor bronchial fistulae open into the empyema and a glossy membrane part fibrous tissue, part outgrowth of bronchial epithelium, lines th cavity medially The implantation of a pedicled muscle graft afte removal by dissection of the lining membrane gives the most satis factory closure Neither un-roofing nor implantation of a muscl graft will result in healing so long as the epithelial lining remains

Tuberculous Empyema.—Tuberculous empyema occurs most often as a complication of artificial pneumothorax. Drainage is in advisable so long as infection with organisms other than the tubercle

bacillus has not occurred. If possible, aspiration is performed in the anterior axillary line so that the needle-track may be distant from any subsequent thoracoplasty incision. Whether the effusion is replaced with air or the lung is allowed to re-expand depends upon the presence or absence of active disease in the lung. After the pleural inflammation has diminished, in many cases extrapleural thoracoplasty is required to close the pleural space and to maintain collapse of the lung.

When mixed infection is present or when a broncho-pleural fistula is present, drainage through the chest wall is necessary. The pleural space is obliterated by extrapleural thoracoplasty when the patient has sufficiently recovered from the initial severity of his illness.

Drainage of Lung Abscess

After diagnosis of a lung abscess, ten to fifteen days are occupied in investigating its pathology and the effect of postural drainage and chemotherapy. If, at the end of that time, the bronchial outlet, because of its narrowness or the presence of a lung-slough, is inadequate to keep the abscess cavity empty, drainage through the chest wall is required.

The segment of rib which most closely overlies the abscess is identified by clinical and radiological means and is resected under local analgesia. If the pleuroperiosteum on the deep surface of the rib shows inflammatory thickening it may be assumed that the two layers of pleura are there adherent. The precise position of the abscess is confirmed by aspiration from it of pus or foul-smelling air. The abscess is incised through the rib-bed and emptied by suction. Enough segments of rib above or below the first are then resected, and their intercostal tissues are removed, to allow excision of the entire outer wall of the cavity, which is then packed with gauze. A piece of the wall is preserved for microscopic examination. The wound is left unsutured and its edges are protected with rubber dam to make removal of the first dressing less painful. The lung pack is changed after five days. The cavity heals by contracture, closure of the chest wall being prevented until this has occurred.

If after resection of rib over the abscess there is no evidence of inflammatory change in the parietal pleura, the presence of adhesions through which the abscess can be drained without contamination of the pleural space is uncertain, and the operation must be performed in two stages. Ribs and intercostal tissues are removed over the estimated extent of the outer wall of the abscess. The wound is packed with gauze, which is left in position for one week. At the end of that time adhesions will be present between visceral and parietal

pleura in the operation area. After removal of the pack the position of the underlying abscess is verified by aspiration. The abscess is incised and emptied and its outer wall excised as in the one-stage operation. Procaine analgesia is unnecessary for the second stage.

Thoracotomy

Most of the intrathoracic viscera can be conveniently exposed by *postero-lateral thoracotomy*. Through the fourth and fifth spaces it gives good access to the upper part of the pleural cavity and for upper lobectomy, through the sixth space for removal of the whole lung, through the seventh for lower lobectomy, and through the ninth for operations on the diaphragm. The spaces below the ninth are too short to permit exploration, and those above the fourth need reflection of the scapula off the chest wall for their exposure.

The patient lies with the side for operation upwards, the leg next the table flexed at hip and knee, the hands before the face. One pillow is placed transversely under the head, one under the chest, and one between the thighs. The shoulder lies directly on the table. A heavy sandbag under the anterior part of the chest pillow prevents the patient from rolling forward Suitably shaped rubber pads and wedges clamped to the table are more secure than sandbag and pillows if the table is to be tilted beyond 5 degrees. An oblique incision 20 to 25 cm (8 to 10 in) long overlying the selected interspace is made through the soft tissues to expose the ribs and external intercostal and sacrospinalis muscles. The sacrospinalis is detached from the ribs at the level of the incision and retracted medially. Two and a half centimetres (1 in) of the ribs bounding the space are resected behind the angle The intercostal vessels are tied and the bundle divided between the resected ribs The intercostal muscles and pleura are then divided in the whole length of the incision, care being taken to avoid adherent lung. If the lung is adherent it is detached from the chest wall to prevent tearing. The pleural cavity is widely opened by means of a self-retaining retractor.

Similar access may be obtained by resecting a long segment of one rib and entering the pleura through its bed instead of through an intercostal space.

When pleural drainage after operation is required, an intercostal Malecot catheter is introduced while the chest is still open in the best position for drainage, usually 5 cm (2 in) above the costophrenic sinus near the scapular line During introduction of the catheter the layers of the chest wall are placed in their normal relationship to prevent later distortion of the catheter. The pleura is not drained through the main incision. The catheter is temporarily closed with a spigot and later attached to a water-seal.

The intercostal wound is closed with a series of stout catgut sutures encircling the ribs above and below it and drawing them together. When these sutures are being inserted the vessels below the lower rib are to be avoided. The pleura and intercostal muscles are repaired with a fine continuous suture. The sacrospinalis muscle is drawn laterally and fixed in position to close the gap left by the resected ribs. The superficial muscles and skin are closed in layers with interrupted sutures.

Anterior thoracotomy may be performed through the second, third, fourth, or fifth interspace on either side for exposure of the mediastinal structures and lung root. The patient lies on his back with the arm of the affected side abducted to a right angle. The incision overlies the space to be opened or curves under the breast to permit its displacement upwards and medially. The pectoralis major muscle is split in the line of its fibres to uncover the second or third space, but over the lower spaces all structures down to the intercostals are divided in the line of the skin incision. Two and a half centimetres (1 in.) of each of the cartilages bounding the exposed space are resected close to the sternum The intercostal muscles and pleura are incised along the space, with care to avoid the internal mammary vessels at its sternal end, and the cartilages and anterior ribs are separated by a self-retaining retractor.

The anterior mediastinal structures can be exposed extrapleurally by division of the sternum in the midline and retraction of its two halves.

Resection of Lung

Pneumonectomy.—Pneumonectomy is employed in the treatment of bronchogenic carcinoma; of bronchiectasis; or of chronic suppuration affecting the whole lung; of non-malignant tumours of the main bronchus not suitable for endoscopic excision, and rarely of pulmonary tuberculosis with bronchial stricture. The patient must be in fair condition and the remaining lung must be healthy. In the case of malignant disease there must be no evidence of metastasis or of invasion of a structure which cannot be excised, and the main bronchus must be free from tumour in its proximal 1·25 cm. (½ in) Any chronic source of pus in the lung is rendered as dry as possible by prolonged postural drainage.

An intravenous cannula is fixed in position for the administration of saline or blood during operation. A postero-lateral thoracotomy through the fifth or sixth space gives good access. The lung is freed from the chest wall, and its root is defined. Dense pleural adhesions may render this the most troublesome part of the operation Part of the dissection may require to be conducted in the extrapleural

tissues. The pleura is divided with scissors on the front and back of the lung root, and pushed medially with the phrenic nerve anteriorly, and strands of the vagus nerve posteriorly. The extension of the fibrous pericardium over the vessels is divided. The pulmonary artery, upper vein, and lower vein in succession are ligated and divided after being cleared by a combination of gauze dissection and by the gentle opening of curved forceps which have been insinuated between them. The length of each vessel available after dissection is usually enough to permit double ligation on the mediastinal side and closure with forceps on the pulmonary side. It may be so short that, while the main trunk can be tied, section must be through the separately controlled branches or tributaries. In some cases it may be necessary to open the pericardium and tie one or more of the vessels as they cross the pericardial space. After ligation of the lower pulmonary vein, the pulmonary ligament is tied and divided. The bronchus is divided between clamps, the proximal clamp being within 1·25 cm. (½ in.) of the main carina The lung can then be removed from the chest. The main bronchus is closed with a row of four or five mattress sutures between the trachea and the controlling clamp, which is then removed The bronchial vessels are included in these sutures. A second row of interrupted sutures is inserted in the cut end of the bronchus. The edges of mediastinal pleura are then drawn together over the bronchial stump and the chest wall is closed without drainage.

The operation is modified when it is performed for malignant disease to show as early as possible any extension of the tumour which precludes its complete removal, and, if none is present, to ensure removal in one block with the lung of all invaded tissues and lymph glands at the bifurcation and along the oesophagus. When the disease originates in the lower bronchus, the lower pulmonary vein should be cleared and its freedom from growth ascertained before dissection of the rest of the hilum. Directly invaded pericardium, diaphragm, or ribs and intercostals can be excised with the lung. Spread along the lung root, obvious malignant deposits in the mediastinal glands, and nodules on the pleura separate from the main tumour contra-indicate pneumonectomy.

Lobectomy.—Lobectomy is suitable for the removal of non-malignant tumours, for bronchiectasis, and for chronic suppuration affecting a single lobe, but it is not an extensive enough resection to be applied to malignant disease (Figs 129, 130)

The approach is postero-lateral, through the fourth or fifth space for the upper and middle lobes, and the sixth or seventh space for the lower lobe. The lobe to be removed is mobilized and the fissures bounding it are defined. When these are absent or shallow, they are



FIG. 129 To show relations of Structures at Root of Right Lung

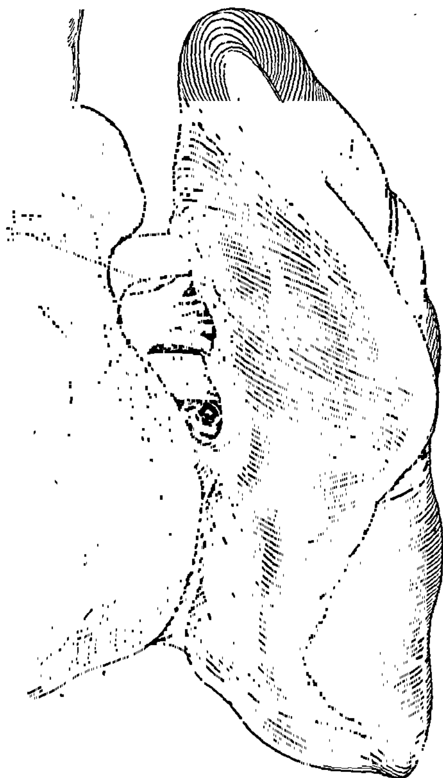


Fig. 130 To show relation of Structures at Root of Left Lung.

extended by division of the lung between clamps, and by oversewing the cut surface with a running suture of catgut. This is most frequently necessary between the upper lobe and the highest part of the lower lobe, and between the upper and middle lobes. The individual structures of the lobar pedicle are exposed by gauze dissection as in pneumonectomy. The residual pleural space is drained to a water-seal for forty-eight hours.

The dissection of the pedicle of the lower lobe is similar on the right and left sides. The artery is found in the interlobar fissure, and postero-medial to it the bronchus. They are exposed in sufficient length to show the distribution of their branches near the fissure. On the right side the artery and bronchus of the dorsal segment arise almost at the level of those of the middle lobe. To avoid occlusion of the middle lobar structures the dorsal branches are tied separately, and the artery and branches to the rest of the lower lobe secured at a lower level On the left side also care must be taken to ligate the artery distal to the lowest branch to the upper lobe. The lower pulmonary vein is found at the upper end of the pulmonary ligament; it drains the lower lobe only.

The dissection of the upper lobe is begun from the mediastinum. On the right side the upper pulmonary vein receives a tributary from the middle lobe, and it must be tied peripheral to their junction. The arterial supply is by two branches, the larger anterior, and the smaller posterior to the eparterial bronchus. On the left side the upper pulmonary vein drains only the upper lobe The left pulmonary artery curves from before backwards above the bronchus of the upper lobe to enter the oblique fissure in which it descends, giving off to the upper lobe usually five branches, each of which must be separately ligated, with care to avoid damage to the parent trunk.

A similar technique of ligation of the individual structures of the pedicle may be employed for removal of the middle lobe, the lingular process of the left upper lobe, and the dorsal segment of either lower lobe

In the performance of lobectomy or pneumonectomy for non-malignant disease, should hilar dissection prove inadvisable because of inflammatory changes or abnormal vascularity, the pedicle is controlled with a snare. The lung is then cut off beyond the snare, leaving a cuff; the vessels and bronchus are closed by interlocking mattress sutures, the snare is removed, and the pleura is repaired with a continuous suture. This operation leaves some lung tissue behind, and it is more frequently followed by bronchial fistula than is hilar dissection, which permits more secure bronchial closure.

Operations for Pulmonary Tuberculosis

The operative treatment of pulmonary tuberculosis is designed to permit relaxation and rest of the affected part of the lung. Rarely drainage of cavities and resection of diseased lung are advisable. Bronchoscopy is used in the diagnosis and treatment of tuberculous ulceration of the bronchi.

Collapse therapy is ideally indicated in unilateral disease with cavitation which is stationary or progressive in spite of rest. In practice its use is extended to cases in which cavitation is absent or in which bilateral disease is present, and for the control of haemoptysis when the source of bleeding is known. It is inadvisable when the vital capacity is so low that further reduction will cause dyspnoea, and when there is major extrapulmonary tuberculous disease.

Artificial Pneumothorax.—Artificial pneumothorax gives equal relaxation of all parts of the lung, and when healing is estimated to have occurred the lung may be allowed to re-expand. It is therefore most widely applicable in the earlier stages when healing may be associated with so little contracture that the lung can again fill the whole pleural space. For its successful induction the pleura must be non-adherent or the adhesions divisible, a condition which can be discovered only by trial

The apparatus consists of a fine trocar and cannula with a side arm. The trocar is grooved from the neck along part of its shaft so that air can pass through the cannula to the side arm while the trocar is in position. The side arm is connected by rubber tubing to a T-glass, one limb of which leads to a water-manometer and the other to a graduated air reservoir. The reservoir is so arranged that, by means of water displacement or some form of piston, filtered air may be drawn into it from the exterior and expelled through the cannula, or made to flow in the reverse direction. The trocar and cannula and the tube connecting the side arm to the T-piece are dry-sterilized as water in the fine lumen of the cannula renders manometer readings unreliable.

With 2·0 per cent. procaine the fourth interspace in the axilla is infiltrated as for paracentesis. The trocar and cannula are inserted until the passage of the parietal pleura is felt and indicated by respiratory fluctuation in the manometer. Air up to 300 c c. is injected into the pleural space without at any time raising the intrapleural pressure above that of the atmosphere. The cannula is then withdrawn and the puncture is sealed with collodion. The pneumothorax is refilled at intervals of a few days until the lung is collapsed to the degree required then at less frequent intervals to maintain collapse. A fluoroscopic examination of the chest

is made before each refill, and not more than 500 c.c. of air are introduced.

Although at first a good respiratory fluctuation is obtained, the pressure may rapidly reach atmospheric level with the inflow of air indicating that the cannula has entered a pleural pocket; the induction cannot be completed at that site. It may prove impossible to find a free pleural space for induction of a pneumothorax, either in the axilla or on the front or the back of the chest.

Complete analgesia for the trocar puncture, demonstration of a free respiratory swing in the manometer before air is allowed to enter the pleural space, avoidance of pleural pressure greater than atmospheric, and restriction of the quantity of air introduced to 300 c.c. are precautions against pleural shock, air embolism, and rupture of an adhesion, which are the immediate complications of induction of artificial pneumothorax.

Closed Intrapleural Pneumolysis.—Adhesions between visceral and parietal pleura, occurring as they do over diseased segments, may prevent satisfactory collapse of a lung after induction of artificial pneumothorax. Their presence can be ascertained by X-ray examination. Whether they are suitable for section can be decided only after endoscopic inspection. The thoracoscope has an optical system for either direct, 45-degree, or 90-degree vision, and it carries a light, the beam of which is projected in the appropriate direction. Under local analgesia a cannula which fits the thoracoscope is inserted through an interspace in the axilla deep to which a pleural space has been demonstrated by aspiration of air. The thoracoscope is passed along the cannula and the interior of the pleural space inspected. Through normal pleura the subpleural structures are clearly visible, but they may be obscured by inflammatory change and by adhesions. For the division of adhesions a second cannula is inserted in the axilla or near the angle of the scapula, again at a point where the pleura is free; the second cannula can be seen with the thoracoscope A cautery adjusted to heat to dull red is passed along the second cannula To avoid damage to the lung and to the extrapleural vessels no structure must be divided until its [illegible]
has been ascertained bey
little difficulty They are
the patient's position With shorter adhesions trans-illumination, with a light in place of the cautery, helps to show the position of lung when that is uncertain. Cautery dissection in the extrapleural tissue over the ribs and the vertebral column may sometimes free closely adherent lung Bleeding from small vessels in the adhesions is controlled by pressure and by heat from the cautery. On completion of the pneumolysis the instruments are withdrawn, the

punctures are closed by skin sutures, and the intrapleural pressure is adjusted.

The expulsion of air into the layers of the chest wall by coughing is frequent after thoracoscopy, and the resulting surgical emphysema causes minor discomfort. During the first three or four days refills are necessary to prevent loss of the pneumothorax.

Haemorrhage into the pleural space is occasionally enough to require treatment. The blood should be removed by aspiration. The possibility of injury to intercostal vessels by the trocar and cannula must be borne in mind. Bleeding from the great vessels because of injury during pneumolysis is rare; it demands immediate thoracotomy and direct control of the damaged vessel.

Damage to the lung by incision, or by interruption of blood-supply which had reached a cavity wall through adhesions, may result in broncho-pleural fistula and empyema, with mixed tuberculous and pyogenic infections.

Extrapleural Pneumothorax.—In patients apparently suitable for treatment with artificial pneumothorax, but without a free pleural space, an extrapleural pneumothorax may be made. The operation is best reserved for disease in the upper part of the lung, with small or medium deeply placed cavities. Cavities which are large and close to the pleura carry some risk of rupture into the extrapleural space.

With the patient in the lateral position the fourth rib is exposed under local analgesia through an incision along the vertebral border of the scapula which is displaced upwards and laterally. Ten to fifteen centimetres (4 to 6 in.) of the fourth rib are resected. By gauze and scissors dissection the parietal pleura is stripped from the ribs, vertebral column, and mediastinum downwards to the hilum of the lung. Dense extrapleural fibrosis may render the separation difficult or impossible to conduct with safety. The space is illuminated by a lamp on a malleable stem Metal clips or diathermy may be used for haemostasis. On completion of the dissection the gap in the fourth rib is closed with periosteum and intercostal tissues to prevent the escape of air from the extrapleural space. The superficial muscles and skin are closed in layers

Obliteration of the extrapleural space must be prevented by aspiration of the blood-stained post-operative effusion and by refills of air at pressures greater than atmospheric Pyogenic or mixed infection of the extrapleural space is the most serious complication.

Extrapleural Thoracoplasty.—Extrapleural thoracoplasty is used where too extensive pulmonary destruction and fibrosis have occurred to permit the lung to fill the hemithorax, or when artificial pneumothorax has been unsuccessfully attempted; but rarely within

six months of the onset of the disease. The collapse caused by it is permanent. Deformity of the chest wall follows, but since the clavicle is intact, is not noticeable when the patient is clothed.

The operation consists in removal of segments of several ribs so that the softened chest wall may fall in. It is performed in stages, three or four ribs being resected in each. The total number of ribs to be resected is determined by the extent of disease in the lung. The procedure is of moderate severity and the contra-indications to any large operation, as well as those to collapse therapy, must be taken into account The patient's condition must be reassessed between stages and if necessary the next stage delayed or abandoned. Local thoracoplasty for disease in the lower part of the lung is sometimes performed, but the typical operation includes resection of the highest ribs.

General anaesthesia may be used. Local analgesia is satisfactory and has the advantages of reducing bleeding from the thick muscle layers round the scapula and of preserving the cough reflex. The line of the incision is infiltrated with 0·5 per cent. procaine with adrenaline. Twenty cubic centimetres of the same solution are injected into the areolar tissue between the scapula and the chest wall, and 5 c c in each of six points for securing towels round the operation area. The intercostal nerves of the ribs to be resected are blocked each with 5 c.c. of 2·0 per cent. procaine near the intervertebral foramen. This may be done after the ribs have been exposed. A brachial plexus block gives greater muscular relaxation but is not necessary for analgesia.

The incision is J-shaped, its vertical limb midway between the scapula and the vertebral spines, and its lower part curving forward below the inferior angle of the scapula. It divides the trapezius, rhomboid, and latissimus dorsi muscles. The scapula is retracted upwards and laterally away from the ribs (Fig. 131). The origin of the serratus anterior muscle from the upper ribs and the insertion of the scalenus medius muscle to the second rib are divided. The sacrospinalis muscle is separated from the highest three ribs The periosteum of the third rib is incised, the rib is cleared with the raspatory, and it is divided The same procedure is followed with the second and first ribs Particular care is taken to avoid damage to the subclavian vessels and brachial plexus where they are in close relation to the first rib The attachment of scalenus anterior muscle to the medial border of the first rib is more easily divided with scissors when it has been made taut by retraction of the rib downwards (Fig 132) After completion of the rib resection, the scapula is allowed to fall back into place and the scapular muscles and skin are repaired in layers

The second and subsequent stages are undertaken after intervals of two to three weeks. The same incision and similar anaesthesia are used. Infiltration of the scar tissue and nerve block above the highest remaining rib are more difficult. Segments of ribs diminishing in length from above downwards are resected. For the lower ribs an extension of the incision running downwards and medially from the curve of the **J** may be required.

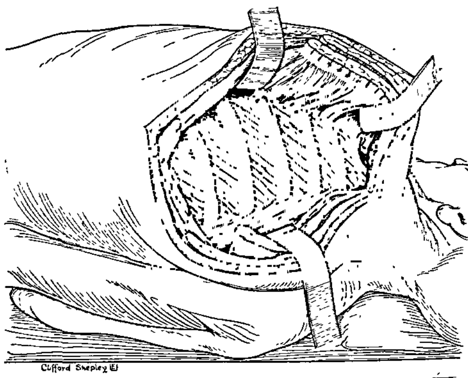


Fig. 131. Thoracoplasty I.

The operation most frequently applicable to disease in the upper part of the lung includes resection of ribs one to three from neck to cartilage, and diminishing posterior segments of ribs four to seven. The dome of the pleura is dissected free from the brachial plexus and subclavian vessels The pleura is stripped downwards from the vertebral column and mediastinum to the level of the lung root, as [illegible] upper [illegible] of their [illegible] After closure of the wound, the scapula occupies a plane deep to that of the intact ribs. The resection of the highest three ribs and mobilization of the pleura constitute the first stage

After operation, pain and the mobility of the chest wall make

coughing difficult so that there is risk of retention of sputum and of pulmonary collapse. Pain is controlled by morphine, and the chest wall is supported by firm strapping until it consolidates. Bronchoscopic removal of sputum may be necessary. Adjustment of position and muscle exercises to prevent scoliosis and to recover shoulder function are continued between stages and after completion of the final operation.

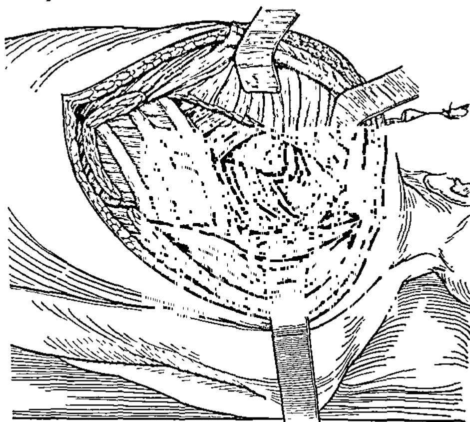


FIG 132. Thoracoplasty II.

Paralysis of the Diaphragm.—Paralysis of the diaphragm relaxes the lung in the vertical direction provided that the diaphragm is free to rise to its position of expiration. The activity of the lower part of the lung is much reduced, a disadvantage when disease is confined to the upper part of the lung. Paralysis by crushing the phrenic nerve is used as a method of securing some temporary [illegible]

[illegible] the diaphragm on a lung partially collapsed by artificial pneumothorax but adherent in the upper part of the chest. Paralysis by section or

evulsion of the nerve is used when it is desired permanently to reduce the size of the hemithorax, when an artificial pneumothorax is being obliterated or abandoned.

The phrenic nerve is exposed through a transverse incision 3 cm. (1¼ in.) long, posterior to the sternomastoid muscle, and a finger-breadth above the clavicle. The incision divides skin and platysma. The posterior border of the sternomastoid muscle and the external jugular vein are retracted anteriorly. Dissection in the fatty tissue, posterior to the sternomastoid muscle, uncovers the scalenus anterior muscle, which is crossed obliquely from its lateral to its medial border by the phrenic nerve. The nerve is deep to the fibrous sheath of the muscle. During the dissection the posterior belly of the omohyoid muscle may appear in the upper part of the wound.

Operations on the Pericardium, Heart, and Great Vessels

Paracentesis.—Paracentesis of the pericardium is performed to obtain specimens of pericardial fluid in diagnosis, and for the relief of cardiac tamponade Local analgesia as for pleural paracentesis is used. The needle is directed upwards and backwards through the angle between the xiphoid process and the left costal margin. Alternatively the puncture may be made 2 cm. (¾ in.) to the left of the sternum in the fifth space, and the needle directed backwards Caution is necessary to avoid damage to the heart wall and coronary vessels There is also risk of injury to the peritoneum, the pleura, and the internal mammary vessels

Exposure of the Heart.—The heart is exposed transpleurally through an anterior thoracotomy in the fourth left interspace, with section of the fourth and fifth costal cartilages. This approach is used for suture of the heart when there is associated pleuro-pulmonary drainage, or continued external bleeding, and for pericardectomy. A similar approach through the fourth right interspace is used for right-sided cardiac wounds

To expose the heart extrapleurally, an incision is made from the third left costochondral joint down the left border of the sternum and outwards along the sixth costal cartilage to the nipple line. The pectoralis major muscle is elevated with the skin flap and retracted to expose the fourth, fifth, and sixth costal cartilages. These are stripped of their perichondrium and resected. The corresponding intercostal vessels are tied at the costochondral junctions, and the internal mammary vessels are tied through the beds of the fourth and sixth cartilages. The tissues of the fourth and fifth interspaces are divided close to the sternum and swept laterally with the pleura from the anterior surface of the pericardium If it does not contain an effusion, the pericardium is more easily picked up after a small

incision has been made in it with a knife. The edges of the incision can then be seized with forceps and the opening enlarged as required.

The extrapleural approach is used for wounds without pleural injury, and for pericardial drainage.

Drainage of the Pericardium.—Drainage of the pericardium is necessary in some cases of suppurative pericarditis. The pericardium is exposed extrapleurally at the left sternal margin. Only the fourth and fifth costal cartilages need be resected. The tissues between them are excised. To maintain the pericardial stoma, its edges may be sutured to the skin.

More dependent drainage is obtained by excision of the seventh left costal cartilage through a 7·5 cm. (3 in.) incision overlying its medial half. The peritoneum and diaphragm are displaced downwards and the areolar tissue between the sternum, heart, and diaphragm is seen. The pericardium is drawn downwards with the areolar tissue, and incised.

Digital exploration of the pericardial space is possible through either approach. Drainage material is not introduced into the pericardium.

Cardiolysis.—When chronic adhesive pericarditis is accompanied by extensive fibrosis in the mediastinum, limitation of movement of the heart in relation to the rigid chest wall appears in some cases to be a factor in the production of cardiac failure. The aim of cardiolysis is to leave a soft and mobile precordium. The earlier stages of the operation are those of extrapleural exposure of the heart The fourth, fifth, and sixth costal cartilages are resected, with 2·5 cm. (1 in.) of the corresponding ribs. The perichondrium and intercostal tissues are excised after separation from the pericardium and the pleura. The musculo-cutaneous flap is replaced and sutured over a soft rubber drain which remains in position for twelve hours.

Pericardectomy.—In those cases of chronic adhesive pericarditis in which venous obstruction is the result of thickening and calcification of the pericardium, which prevents proper filling of the heart in diastole, excision of the pericardium is indicated.

The pericardium is exposed by the extrapleural approach. An incision parallel to the anterior branch of the left coronary artery is made in the pericard[illegible]

from the left ventricle. Great care is required to avoid tearing the heart wall If further freeing of the heart appears necessary the fibrous coat may then be cleared from the right ventricle or this may be postponed until a second stage after reassessment of the patient's symptoms. The superficial wound is closed as after cardiolysis.

Ligation of the Patent Ductus Arteriosus.—Ligation of the patent ductus arteriosus is indicated when no other congenital cardiac defect is present and symptoms such as retardation of development and dyspnoea on slight exertion are the result of patency of the ductus. Ligation has a favourable influence on the course of subacute bacterial endocarditis superimposed on a patent ductus.

The approach is through the left pleural cavity either by an anterior incision in the second interspace with division of the second and third costal cartilages, or by a postero-lateral incision in the fifth interspace. The latter permits a wider exposure of the upper mediastinum The mediastinal pleura is incised over the aorta and pulmonary artery lateral and parallel to the phrenic nerve. The pleural edges are swept apart and the vagus nerve and its recurrent branch curving under the aortic arch are identified. The ductus lies close on the medial side of the recurrent nerve. By dissection with blunt artery forceps in the areolar tissue between the aorta and pulmonary artery, and between the ductus and the left bronchus, the ductus is cleared. The posterior dissection is done blindly. The ductus is then doubly ligated with silk as close as possible to the aorta and pulmonary artery. The lung is inflated and the chest wall is closed without drainage.

Operation for Diaphragmatic Hernia

Repair is indicated in all cases of traumatic hernia and in those cases of congenital hernia in which symptoms are more than trivial. General anaesthesia is used Postero-lateral thoracotomy through the ninth space gives satisfactory access to the diaphragm Hernia through the costo-xiphoid gap is more easily exposed through an anterior incision in the fifth space

The sac of a congenital hernia is excised, its contents are restored to the abdomen, and the edges of the diaphragmatic gap are overlapped with a double row of silk mattress sutures, peritoneum, diaphragm, and pleura being treated as a single layer.

When the hernia passes through the oesophageal hiatus the sac is deep to the mediastinal pleura Enough room to admit a finger alongside the oesophagus must be left after suture of the diaphragm.

The sac is absent in traumatic hernias There may be extensive adhesions of abdominal to thoracic viscera if the hernia is of long duration. Omentum tends especially to be adherent to pericardial fat, to the site of an old chest-wall injury, and to the margins of the diaphragmatic defect. The abdominal structures are replaced, and the diaphragm is repaired as in congenital hernia Closure of the defect rarely presents difficulty If it is so close to the chest wall that

there is no peripheral flap of diaphragm, the central edge may be attached by mattress sutures passing through the intercostal muscle.

(Operations on the OESOPHAGUS are described at page 201.)

OPERATIONS FOR INJURIES OF THE CHEST

During resuscitation after severe chest injury measures to restore the efficiency of respiration may be necessary. An open pneumothorax is closed with a secure dressing. Mediastinal displacement is reduced by withdrawal of air from the pleural space. Mucus lying in the trachea and bronchi, if it cannot be expelled by the patient's own coughing effort, is removed by suction through an endotracheal catheter or bronchoscope. If cough has been suppressed because of pain from fractured ribs, procaine block of the corresponding intercostal nerves may enable the patient to cough effectively. Oxygen is given by mask or catheter. Blood loss is restored by transfusion.

Ligation of intercostal vessels may be required to control bleeding from lacerations of the chest wall

The haemothorax which accompanies most wounds which penetrate the pleura, and some closed injuries, is treated by aspiration of blood from the pleural space, to secure early expansion of the lung and to reduce the risk of pleural infection. Aspiration may be begun twenty-four hours after injury without causing recurrence of bleeding. The pleural space is emptied, if this can be done without distressing the patient, and aspiration is repeated when the effusion recurs

In some cases massive clotting prevents aspiration of the blood, and, if the quantity is large, thoracotomy is undertaken for its removal two to four weeks after injury. At the same time the fibrinous deposit on the visceral pleura is dissected away as in the operation of decortication for chronic empyema (p. 303)

The operative treatment of infected haemothorax is similar to that of empyema.

An open pneumothorax urgently requires operation for its repair. Soiled and necrotic tissue is excised from the chest wall, loose fragments of rib are removed, and damaged intercostal vessels are ligated. Through the pleural opening, extended if necessary, blood and foreign material are removed from the pleural space, and the lung is inspected for penetrating rib spicules. The muscular layers of the chest wall are sutured to give air-tight closure of the defect. The skin is left unsutured

Thoraco-abdominal wounds are explored through a posterolateral thoracotomy in the ninth space. The pleural cavity is emptied of blood. The diaphragmatic wound is enlarged and the

subphrenic viscera inspected, and, if necessary, repaired. This approach is satisfactory for wounds of the liver on the right, and of stomach, spleen, splenic flexure of colon, and kidney on the left The gap in the diaphragm is repaired with interrupted sutures, the lung is inflated, and the chest wall is closed. If, because respiratory disturbance is slight and there is evidence of a lower abdominal lesion, laparotomy is performed for a wound of the diaphragm, the same anaesthetic precautions are required as for thoracotomy, since air will enter the pleural space through the diaphragm before it can be repaired

Other indications for thoracotomy are rare. They are wounds of the lung opening a large bronchus, wounds of the oesophagus, and rapid reaccumulation of blood in the pleural space after aspiration. The intercostal and internal mammary arteries are the most probable sources of continued bleeding.

When it is known, from the presence of a precordial wound, or from the estimated track of a penetrating wound, that an injury to the heart is the source of continued bleeding, either externally or into the pleura, the heart is exposed through an anterior intercostochondral thoracotomy After the pericardium has been opened the wound in the heart wall is controlled by finger pressure during the insertion of sutures for its closure. Traction on a suture through the muscle of the cardiac apex may be necessary to bring a wound of any but the anterior wall into view. The opening in the pericardium is only partly repaired so that fluid may escape from it into the pleural cavity

When the pleura is intact the extrapleural approach is used for suture of cardiac wounds

A L.

CHAPTER XX

OPERATIONS ON THE BREAST

Anatomy. Operations for Mammary Abscess. Simple Tumours. Malignant Disease. Indrawn Nipple.

Anatomy.—The mammary gland lies in relation to the subcutaneous tissue of the antero-lateral chest wall. Embedded in and partly overlaid by the subcutaneous fat, it maintains an association with the overlying skin through the medium of bands of fibrous tissue (suspensory ligaments of Cooper) which pass from the deep surface of the skin to merge in the aponeurotic tissues of the gland. Its deep surface is in contact with the plane of deep or pectoral fascia overlying the pectoralis major muscle. Its *extent* is from the lower border of the second rib to the lower border of the sixth costal cartilage in the vertical plane, and from the edge of the sternum to the mid-axillary line in the horizontal plane. From the supero-lateral quadrant a portion of mammary tissue, the *axillary tail* (Spence), extends upwards into the axilla as far as the third rib. The deep surface of the gland lies in relation to the following muscles—pectoralis major, pectoralis minor, serratus anterior, and external oblique. For descriptive purposes it is convenient to [illegible]

mammary branch of the axillary artery, from the second, third, and fourth perforating branches of the internal mammary artery, and from the lateral branches of the intercostal arteries The venous blood returns to the axillary, cephalic, external jugular, and intercostal veins.

The *nerve supply* to the skin overlying the breast is derived from the descending cutaneous branches of the cervical plexus, and the lateral and anterior cutaneous branches of the second to the sixth intercostal nerves The mammary tissue derives its sensory supply from the perforating terminal branches of the third, fourth, fifth, and sixth intercostal nerves. In addition there is a considerable sympathetic innervation derived from the thoracic sympathetic distributed by way of the arteries and concerned with the activity of the muscular tissue of the breast and the secretory functions of the ducts and acini.

The *lymph vessels* are conveniently described as existing in two groups, the cutaneous and the glandular The *cutaneous lymphatics* circulate in the deep layer of the skin in continuity with the general arrangement of superficial lymphatics They establish communication with the glandular lymphatics at two areas—around the nipple, the subareolar plexus of Sappey, where they anastomose with the periductal lymphatics, and at the various points at which the suspensory ligaments (Cooper's ligaments) pass from the deep surface of the skin to the mammary stroma The *glandular lymphatics* originate in the peri-acinar spaces, they pass in a centripetal manner towards the centre of the mamma, from which point they are distributed in two directions, towards the nipple to anastomose with the subareolar plexus, and backwards through the centre of the gland to communicate with the fascial plexus overlying the pectoral muscles.

The lymph field of the breast has two important adjacent associations; it is in continuity with the mammary area of the opposite side, and in its infero-lateral quadrant with the subperitoneal lymphatics of the upper abdominal

rea and the capsule of the liver. Lymph from the breast drains into a variety of lymphatic glandular areas: the majority of the vessels pass through the medium of several large trunks into the pectoral chain of the axillary group, there are other [illegible]
the circumflex [illegible]
pectoral chain [illegible]
the mammary area passes to the subclavicular glands lying on the costo-coracoid membrane, to the supraclavicular and scalene groups of glands, to the internal mammary and sternal groups, and by a circuitous route which follows the line of the intercostal vessels to the vertebral and para-aortic glands.

Operations on the Breast

Operations for Mammary Abscess.—Abscesses arising in relation to the breast are of three types, only one of which is a true mammary abscess The types are the *pre-mammary* or *subcutaneous abscess*, the *mammary abscess* arising within the breast-tissue, and the *retro-mammary abscess* developing in the areolar tissue which separates the breast from the pectoral fascia, a type which usually originates in the skeletal tissue of the chest wall. The operative procedure varies in each type.

The *pre-mammary abscess* necessitates an incision of appropriate size and position The contents of the abscess are expelled, and drainage is secured by means of a narrow strip of dental rubber.

The *mammary abscess* is usually situated in the periacinar and periductal tissues, it is therefore often multiple in character, the breast stroma forming fibrous partitions between the various individual collections To evacuate the abscess an incision is planned which radiates from the nipple It is important that the incision shall not encroach upon the areola in case the areolar venous sinus be opened or a duct ampulla incised. After incision the finger is introduced into the cavity and any septa which might interfere with efficient drainage are broken down. Strips of dental rubber are now introduced into the main sites of the collection, and if necessary, counter-openings are made at the periphery of the infected area.

The *retro-mammary abscess* is evacuated through an incision which lies in the line of the thoraco-mammary fold. The incision is deepened until the deep fascia is reached, the lower edge of the breast is defined, and the plane of the retro-mammary space entered. The breast is then separated forwards until the abscess area is exposed If the infection is of a pyogenic nature, drainage is established, and the breast is then allowed to fall back into place. If the infection has been a tuberculous one originating in the underlying skeleton, the sinus connecting abscess and primary focus is traced until the point of the original infection is exposed, and, if possible, eradicated. Thereafter the wall of the abscess cavity is gently curetted, an anti-

septic, such as Bipp, being rubbed into the wall, the breast is replaced in position, and secured by several interrupted catgut sutures; the skin wound is then closed without drainage.

Operations for Simple Tumours and Cysts.—If a simple solid tumour, such as a fibroma, occupies the superficial area of the mamma, it may be exposed through an overlying radiating incision. After division of the superficial tissues the breast-tissue is incised and

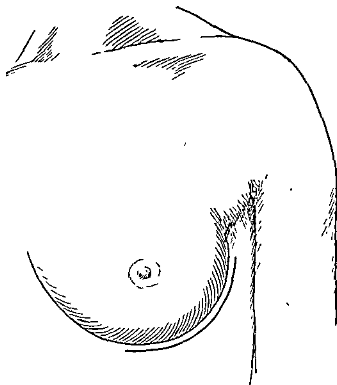


FIG. 133. The Gaillard Thomas Incision for Exposure of the Retro-mammary Space, and for Local Excision of the Mammary Gland.

the tumour shelled out. The cavity remaining is closed by several interrupted catgut sutures, and drainage is provided for.

If the tumour occupies the deeper portion of the breast, or if a pre-mammary incision is objected to for aesthetic reasons, the method of retro-mammary access suggested by Gaillard Thomas may be employed A curved incision (Fig. 133) following the thoraco-mammary fold is made from the nipple line to the anterior axillary border and the posterior surface of the breast is separated from the pectoral fascia until the portion overlying the tumour is exposed. The mammary tissue is now incised, the tumour is shelled out, the space obliterated by suture, and drainage established. The breast is thereafter replaced and the superficial tissues united.

If the condition demanding operation is a single cyst, the procedure is similar to that adopted in simple tumours, but, as it is usually impossible to 'shell out' the cyst wall, a wedge-shaped segment of breast-tissue, including the cyst, is removed.

When the breast is the site of a *diffuse* or *multiple* yet simple pathological condition, such as multiple cystic disease, the entire breast may be excised by the Gaillard Thomas method. Following an incision in the thoraco-mammary fold (Fig. 133) the posterior surface of the breast is separated from the underlying muscles and fascia until the area is free. The breast is then dissected away from the overlying skin, the larger ducts being divided at their attachment to the nipple. Following removal of the gland all bleeding is arrested, the tissues on the deep surface of the nipple are sterilized by the application of an antiseptic, and the skin is allowed to fall into place. Free drainage of the subcutaneous space is required.

So far as the scar is concerned, the disfigurement of the operation is relatively slight, as the wound is concealed in the submammary fold, but adhesion of the skin, and particularly of the nipple, to the underlying muscles may result in unsightly puckering of the parts.

Under certain conditions it may be desirable to combine the local excision of the gland with removal of the nipple and a certain amount of skin; in this event an elliptical pre-mammary skin incision is employed.

Malignant Disease of the Breast.—It is agreed that if operative treatment of malignant disease of the breast is to yield satisfactory results the amount of tissue removed must be extensive. The extent of the operation has been gradually increased, and it is now considered necessary to remove (1) the mammary gland together with the surrounding fat and an area of skin overlying the tumour and including the nipple, (2) the pectoral muscles with their related fasciae; (3) the deep fascia which overlies the serratus anterior, the external oblique, and the upper part of the rectus abdominis; (4) the fat, lymph-vessels, and glands which occupy the axilla, and the clavipectoral space (costocoracoid) If there is evidence that the supraclavicular glands are infected, they also should be removed.

The steps of the operation may be described as follows. It is important that an extensive *skin sterilization* be carried out; the preparation is therefore from the nipple of the opposite side to the midline of the back, and from the root of the neck to the level of the umbilicus. The patient lies on her back, and the arm is held by an assistant in a fully abducted position The skin *incision* should be adapted to the situation and extent of the tumour, but in general it will be found satisfactory to employ one which crosses the axilla about the centre from the posterior to the anterior wall; it then

extends obliquely downwards over the breast, bifurcating to include the nipple and the skin which overlies the tumour, it reunites, and is continued in an oblique direction to beneath the costal margin of the opposite side (Figs. 134, 135). There are advantages in carrying out the axillary dissection before removal of the breast: it permits a block dissection by which glands, fascia, and muscles are removed in continuity, the blood-vessels encountered in the later stages of the operation are efficiently controlled, and the removal of the pectoral muscles, which entails considerable shock, is delayed until towards the termination of the procedure. The technique to be described adopts the plan of a preliminary axillary dissection.

Dissection of the Axilla.—That portion of the incision which overlies the axilla is deepened over an extent affording sufficient access. The dissection is then continued by a reflection of the skin and subcutaneous tissues until the exposure is made of the great pectoral muscle where it overlies the axilla, and of the basal fascia of the axilla extending from the inferior edge of the pectoralis major muscle to the axillary border of the latissimus dorsi muscle and from the chest wall to the medial surface of the upper arm. The lower edge of the pectoralis major is now defined by sharp dissection, and at a higher level a separation is made between the sternal and the clavicular fibres of the muscle. The edges of this second plane of separation are retracted in order to expose the thoraco-acromial vessels where they pierce the costocoracoid membrane close to the upper border of the pectoralis minor muscle in relationship to the lateral anterior thoracic nerve; the vessels are clamped and divided. The finger is passed beneath the muscle to emerge through the plane of separation, and the isolated portion is divided close to its insertion into the humerus. The central portion of the muscle is retracted medially, thus exposing the pectoralis minor and the costocoracoid membrane (Fig 136) The vessel supplying the pectoralis minor arises from the long thoracic artery, and it is clamped as it enters the deep surface of the muscle at the inferior border. The tendon of the pectoralis minor is now isolated by the finger and divided. Both pectoral muscles are retracted medially, and the axillary space is thrown open to dissection This dissection is efficiently accomplished by means of a pledget of gauze, the separation beginning where the axillary veins enter the upper arm That portion of deep fascia which covers the vein is divided, and the separation of fat, fascia, and lymphatic tissue is carried medially along the vessels until the apex of the axilla is reached. The lateral thoracic and certain unnamed vessels are clamped and divided close to the main trunks, the subscapular and the superior thoracic vessels are preserved. The lateral branch of the second intercostal nerve (the intercosto-brachial) is encountered as

it passes across the axilla from the medial to the lateral side. It is customary to divide it at its point of emergence from the chest wall and to remove the portion related to the axilla. The dissection of the posterior wall of the axilla is now completed, and the fascia with its related fat is stripped downwards and medially from the ventral surface of the muscles which form the posterior wall of the axilla—

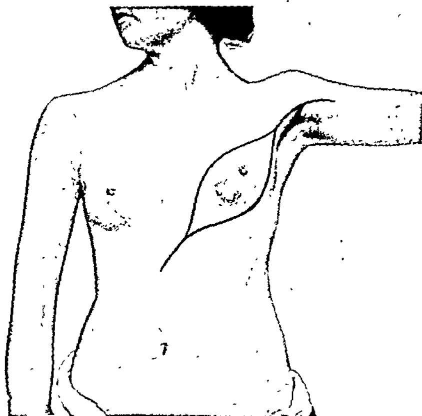


FIG 134 Incision for Operation for Carcinoma of the Breast.

the latissimus dorsi, the teres major, and the subscapularis. As the lateral portion of the posterior wall is reached a more complete definition of the subscapular vessels is made, and the three subscapular nerves—the short subscapular, the thoraco-dorsal, and the lower subscapular—are exposed Where the inferior angle of the scapula comes into contact with the chest wall a venous anastomosis between the subscapular and the lateral thoracic veins is encountered,

this manœuvre the preliminary dissection of the axilla is completed, all bleeding is arrested, and the parts are covered with a sterile towel soaked in warm saline.

Exposure of the Breast.—The long oblique incision originally outlined is completed, and the edges are dissected free so as to expose the breast and the surrounding tissues. The dissection is done on a

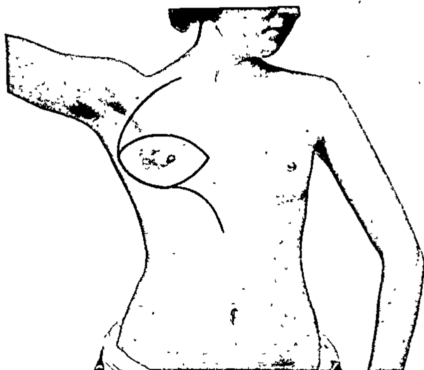


Fig 135 Incision for Operation for Carcinoma of the Breast, the Tumour being Central.
(After Kocher)

'bevel' principle, cutting close to the skin at the point of incision and gradually deepening the plane of cleavage as the periphery of the dissection is reached. This plan is adopted in order to ensure the subsequent removal of the subcutaneous tissues in which diseased lymphatics may run. The superficial separation is continued until certain landmarks are reached—the clavicle above, the breast of the opposite side medially, the upper abdominal segment and costal margin below. When this stage is completed the breast is removed, but it is the aim of the operator that the axillary contents already dissected—the deep fascia of the chest wall, and the breast with the pectoral muscles—shall be removed in continuity. An incision is therefore made through the deep fascia of the lateral chest

wall (Fig. 137), beginning at the point where the latissimus dorsi muscle leaves the chest wall to enter the axilla, and thence sweeping in a curved manner convex downwards across the lower ribs and the costal margin, and over the upper portion of the rectus abdominis muscle to the middle line. The assistant holding the contents of the

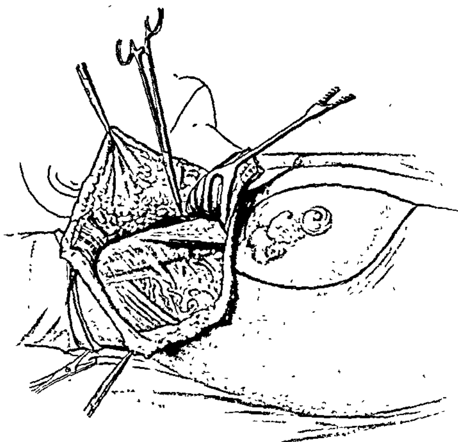


FIG. 136 Radical Excision of the Breast. Preliminary Dissection of the Axilla.

The pectoralis major muscle has been divided close to its insertion and is being retracted medially. The costocoracoid membrane, the thoraco-acromial vessels, and the pectoralis minor muscle are exposed

axilla, the operator proceeds to separate the fascia along the line of division from the underlying serratus muscle. As the separation is continued upwards and medially, it enters the space beneath the pectoralis minor muscle, and at this point the lateral branches of the intercostal arteries are exposed and clamped. Further separation carries the dissection beneath the pectoralis major, and as the lateral border of the sternum is approached the anterior perforating branches of the intercostal vessels are isolated, secured, and divided (Fig. 138). With a few touches of the scalpel the further attachments of the

muscle are divided, the upper end of the rectus abdominis muscle is cleared of fat and fascia, and the separated parts are removed. All bleeding is arrested, and the parts are covered with warm towels soaked in saline solution.

Final Dissection of the Axilla.—The operator now returns to the axilla, the removal of the breast and the pectoral muscles having afforded freer access more particularly to the region of the apex.

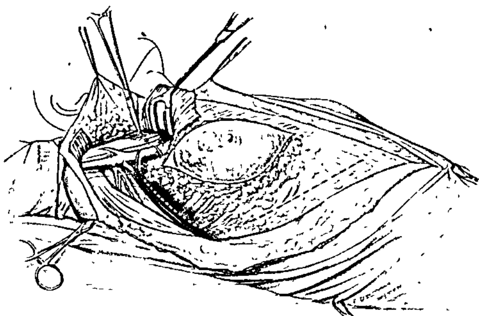


FIG. 137. Radical Excision of the Breast.

The preliminary dissection of the axilla has been completed The breast has been freed from the overlying tissues, and the incision through the deep fascia of the chest wall has been outlined

By appropriate retraction the tissue spaces around the vessels and the cords of the brachial plexus are exposed, and all lymph-bearing and fatty tissues are removed. Particular attention is paid to the space beneath the clavicle and around the subclavius muscle, to the apex of the axilla, and to the point at the lateral edge of the posterior wall of the axilla where the circumflex scapular artery winds round the edge of the subscapularis muscle to reach the infraspinous fossa

Closure of the Wound.—The wound edges are adapted to one another and sutured with a series of interrupted silkworm gut stitches and with Michel's clips Where there is undue tension on the wound edges it may be lessened by 'under-cutting', and, if the skin vitality is open to question at any point after suture, cross-scoring with the point of the knife may afford relief (C. H. Mayo).

If it should prove impossible to close the wound completely,

Thiersch grafts cut from the skin of the thigh and held in place by stent supports may be applied, or the wound may be allowed to granulate and be grafted at a later date.

Drainage is secured by means of a glass or rubber tube introduced through a puncture wound at the level of the posterior border of the axilla, the central end of the drain resting in the upper portion of the

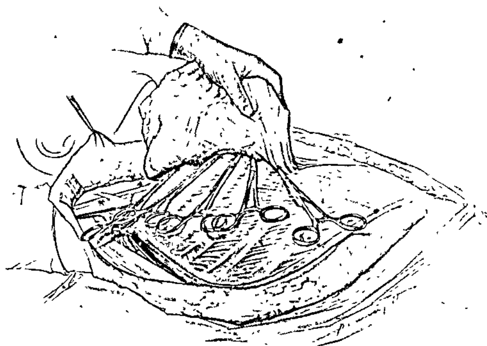


FIG 138 Radical Excision of the Breast.

Following the separation of the fascia of the chest wall the pectoral muscles, with the overlying breast, are dissected off the chest wall The lateral branches of the intercostal arteries have been ligated, and the anterior perforating branches are exposed

axilla. A large dressing of dry sterile gauze and wool is applied, and a broad sterile domette axillary bandage holds the dressing in place When the patient returns to bed the arm is supported by pillows so that it is abducted at the shoulder, and the patient is encouraged to use the arm and hand

The dressing is changed forty-eight hours after the operation, when the drainage-tube is removed The clips are taken out on the fifth day, and the stitches on the eighth day As a rule the patient may be allowed to get out of bed on the tenth day.

Operation for Congenital Retraction of the Nipple.—In view of the significance attached to the influence of congenital retraction of the nipple on the occurrence of malignant disease of the breast, operation is sometimes practised for the relief of this condition.

Operative interference may also be indicated for aesthetic reasons or to permit suckling of an infant.

The operation is of a plastic nature, and the procedure is illustrated in Fig. 139. A series of V-shaped incisions with the apices towards the nipple are made in the skin of the areola. They are deepened until the periductal tissues are reached, a silkworm gut suture is then

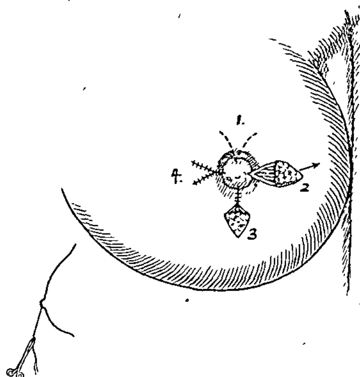


Fig. 139 Plastic Operation for Elevation of a Depressed Nipple

The steps of the operation are illustrated *seriatim* The small inset figure illustrates the method of securing the nipple until healing is complete.

passed through the centre of the sunken nipple, and the depressed parts are elevated. When the position is satisfactory, the skin edges are sutured in a Y-shaped fashion with horsehair or silkworm gut stitches In order to prevent retraction of the parts the stitch which was passed through the nipple is attached to the skin below the breast, so as to exert a reasonable amount of tension, or traction is secured by attaching an artery forceps or small weight to the nipple suture

J. F.

CHAPTER XXI

GENERAL TECHNIQUE OF ABDOMINAL SURGERY

Preparation for Operation. Operative Technique. Post-operative Care. Complications

THE procedures common to all operations on the abdominal viscera are dealt with in this chapter to avoid repetition in describing individual operations.

Preparation for Abdominal Surgery.—*The patient about to* undergo laparotomy should be admitted to hospital some days before operation This is not possible in urgent and emergency conditions, but even the 'acute abdomen' will benefit from a short delay during which such obvious physiological disturbances as shock and dehydration are corrected. The waiting period enables the patient to become accustomed to hospital routine and to the nursing staff and medical attendants. Confinement to bed is unnecessary in *the majority of cases, in fact activity should be encouraged,* and it is an advantage to institute routine breathing and abdominal exercises Male patients should learn to use a urinal in the recumbent position

The few days' grace permits a thorough pre-operative survey; the discovery of any complicating condition such as diabetes, urinary infection, or anaemia may make it desirable to abandon or postpone operation, or it may influence the choice or the scope of the operative procedure.

The condition of teeth and gums should be ascertained on admission, for untreated dental infection may be followed by post-operative parotitis, and it may also favour the development of respiratory infections A strict routine of oral hygiene should be established after any necessary dental treatment has been completed. Chemical and microscopic examination of the urine should be carried out and, especially in older subjects, the fluid intake and output contrasted and adjusted A routine blood examination is also advisable; the red cell count is often diminished, and the haemoglobin reduced in elderly subjects. The blood group should be determined, and arrangements made to have a supply of compatible blood available during and after operation.

Operation may have to be delayed to permit special methods of preparation in pyloric stenosis, in diseases of the large bowel, in jaundice, and in the presence of obvious dehydration or of hypoproteinaemia. In *pyloric stenosis* gastric lavage should be instituted, and suitable measures *adopted* to restore the protein *and fluid-*

electrolyte balance. In *surgical lesions of the large intestine* a preliminary course of sulpha therapy reduces the bacterial flora of the gut; sulfasuxidine or another of the relatively unabsorbable preparations should be used. In *jaundice* the risk of post-operative haemorrhage is reduced by preliminary saturation with vitamin K, and the risk of liver failure diminished by a high protein, high carbohydrate diet. *Dehydration* and *protein deficiency* are most commonly seen in conditions associated with vomiting and starvation (as in pyloric stenosis and malignant disease); both may influence the patient's ability to withstand serious operative procedures, and both retard healing. In common with other forms of trauma, laparotomy is associated with marked and rapid post-operative protein destruction, and a dangerous nutritional level may soon be reached if a patient, already in a state of protein deficiency, is submitted to operation.

The intake of protein can be increased by a high protein diet, by the oral use of supplementary protein preparations, or by intravenous infusion of protein hydrolysates or blood plasma If the patient is able to take food, the aim should be a daily intake of 150–200 grammes of protein. In anorexia this is a matter of difficulty, and then recourse may be had to the administration of hydrolysed protein preparations through a duodenal tube. In pyloric stenosis there may be no alternative but to counter the protein deficiency by repeated plasma infusions

Hypoproteinaemia is generally accompanied by vitamin deficiency, and lack of vitamin C is especially important in abdominal surgery, since this vitamin is also intimately concerned with the processes of repair. In particular, it is essential for the formation of collagen, on which the strength of scar tissue depends; and in association with protein deficiency it may predispose to disruption not only of the laparotomy wound but also of gastro-intestinal anastomoses. One of the many multi-vitamin preparations should therefore be administered, or ascorbic acid itself prescribed.

Immediate Pre-operative Preparation.—The intestinal tract should be empty and at rest at the time of operation. Purgation must be avoided, and if there has been a regular daily evacuation of the bowel, a small bland enema on the morning of operation is adequate preparation. If the patient has been previously constipated, an aperient may be administered not later than the morning of the day preceding operation, followed by a soap and water enema on the morning of operation

The diet should be light and leave little residue; orange juice with glucose added should be given with each meal, and plenty of fluids allowed between meals. On the morning of operation, a cup of tea

or coffee without milk is permissible if the patient wishes it, but nothing should be allowed by mouth within three hours of the operation.

Smoking should be reduced to a minimum and forbidden altogether on the day of operation. An abrupt and complete prohibition for longer than this may make the patient very miserable, and no harm results from allowing a cigarette after meals on the day before.

On the night before operation the patient is given a bath, or is sponged down in bed, and the operative field is shaved and disinfected. The area of skin preparation should be liberal, extending from the pubis to the level of the nipples, and after sterilization it should be covered with a light sterile dressing.

Sleep is ensured by the use of a sedative, selected after consultation with the anaesthetist.

Before the patient is taken to the theatre, the bladder must be emptied, if necessary by catheter; dentures should be removed, and the patient kept warm by long woollen stockings and a garment which will allow ready exposure of the field of operation.

Position on the Operation Table.—The position of the patient on the operation table varies with the incision to be used and the part of the abdomen to be explored, it is an important aid to subsequent exposure Extreme distortion of the trunk or limbs should be avoided and unusual postures, such as hyperextension of the back over a 'kidney bridge', should be maintained for as short a time as possible, as they are liable to lead to considerable, and occasionally prolonged, post-operative discomfort or pain

The table should be well padded, and after the proper position is secured the arms should be anchored at the side of the trunk, preferably by bandaging the wrists to the table. On no account should the hands be placed beneath the buttocks.

For the majority of abdominal operations the ordinary dorsal position is the most convenient, and the heels may be supported by sponge rubber pads in such a way that compression of the calves, which may predispose to thrombosis of the intramuscular veins and consequently to pulmonary embolism, is avoided.

When it is necessary to obtain access to the pelvis, the Trendelenburg position has many advantages The patient lies at a plane inclined about 45°, with the pelvis and thighs raised and the legs hanging over the end of the table, sliding from the table is prevented by means of shoulder supports, and not by the flexion of the legs over the end of the table, which puts strain on the abdominal muscles The intestines are displaced towards the diaphragm by gravity, and the pelvic organs are brought within easy reach Care must be taken that respiration is not impeded by the pressure of

the viscera on the diaphragm; and at the end of the operation the patient should be returned to the horizontal position gradually lest a sudden change induce syncope from acute cerebral anaemia.

The biliary passages can be made more accessible by tilting the head end of the table upwards—a 'reversed Trendelenburg' position —and by placing a pneumatic cushion under the lower ribs.

For exposure of the kidney by the lumbar route, the patient is placed on his side—*the lateral position*—and a round cushion is inserted under the loin to increase the space between the costal margin and the iliac crest. To maintain this posture, the hip and knee of the lower limb are fully flexed, and the upper limb is fully extended in the axis of the trunk. A sand pillow beneath the lower knee helps to prevent the patient rolling out of position; the arm which is uppermost is supported on an arm-rest.

General Technical Considerations.—Careful technique does much to make the convalescence after laparotomy smooth, and to prevent or minimize complications. Foremost of the technical demands of good abdominal surgery is gentleness; strong retraction of the wound edges, rough handling of the intestine, excessive use of abdominal packs, and mass ligations are potent causes of such later troubles as wound sepsis, post-operative ileus, and adhesions.

Good illumination is essential, and the lighting should be carefully arranged before the start of the operation. Adequate and well-planned incisions resolve many difficulties, and will often obviate the need for retractors, and make the control of bleeding simple. The tempo of an abdominal operation should be quiet and unhurried; advances in modern anaesthetic methods have eliminated the need for excessive speed, but time should not be squandered on indecisive and haphazard manœuvres and manipulations. The steps of most abdominal operations can be standardized and their sequence made a matter of routine practice with which assistants and staff can readily become familiar.

It is an advantage to retain the same operating team, and they should be briefed thoroughly before the start of the operation so that the operator's wants can be intelligently anticipated.

It is good practice to institute a drip blood transfusion immediately before the start of any operation that is likely to be of long duration, or liable to be associated with much blood loss. In other cases infusion fluids or blood and restorative drugs should be readily available. The anaesthetist should assume charge of such resuscitative measures: he is familiar with the patient's condition from his pre-operative examination, and he is in a position to make accurate observations of the pulse-rate, blood-pressure, and respiratory rate throughout the course of the operation.

When the proper position on the operation table has been secured, the chest and limbs are suitably covered, only the abdomen being exposed. *These preparations should if possible be carried out in the* anaesthetic room or ante-theatre; the necessary manipulations cause considerable atmospheric disturbance, and adjustment, especially of blankets, charges the air with organisms and particulate matter. It is an added safeguard if blankets used in the theatre are enclosed in linen slips or covers

The anaesthetic room and theatre must be well heated; the patient does not then need abundant coverings, which tend only to increase *sweating and fluid loss.*

The skin is re-sterilized in the theatre, and the operative field is isolated by a series of sterile drapings which completely cover the chest and limbs Sterile rubber sheets may be used beneath the linen, in hot theatres and in hot climates, however, their use prevents evaporation of sweat and contributes to serious disturbance of the temperature-regulating mechanism, and to heat stroke.

Abdominal Incisions.—A satisfactory incision must be adequate *in length, and be capable of some degree of extension without* damage; it should be so situated that it gives the best possible access to that part of the operative field which is likely to present the most difficulty, it should interfere as little as possible with the respiratory function of the abdominal wall in the immediate post-operative period, and it should leave a strong and durable scar.

If the incision is of reasonable length to begin with, much enlargement should not be required, but difficulty may arise if the original diagnosis has been wrong. This situation is not uncommon in acute abdominal emergencies, as when a suspected perforated duodenal ulcer is discovered to be a perforated appendix. In such cases it is generally wise to close the first wound and to make a new more suitable incision. The convenience of the new approach and the gentleness with which the operation can be conducted more than balance the trifling prolongation of the operating time.

The anatomical structures to be spared as far as possible are nerves and muscles The nerves of the abdominal wall course in the interval between the internal oblique and the transverse muscles towards the rectus sheath. the upper trunks pass horizontally or even slightly upwards, while the lower incline downwards and medially. They are therefore spared by oblique incisions in the interval between adjacent nerves, which is approximately 5 cm (2 in)

Incisions through muscle heal by fibrous tissue, and if this is sufficiently strong, no harm results However, separation of muscle-fibres is always preferable to division, *for the resulting scar is not*

then subjected to distracting stresses, and there is minimal interference with the functional activity of the muscle. Laterally placed oblique incisions are therefore better than vertical approaches which cut across the line of the lateral abdominal muscles.

There is no standard operative approach to the abdominal contents; the choice of incision depends on such factors as the organ to be explored, the age and build of the patient, and the accuracy of the diagnosis. Modifications may be demanded by the need for speed, by the acuteness or otherwise of the pathological condition, and by the presence of scars from previous operations. In general, vertical incisions in or near the midline are favoured for operations on the stomach and pelvic viscera, and when the diagnosis is in doubt, or speed is important, as in perforated peptic ulcer.

Oblique incisions are more commonly employed in the elective surgery of the colon, appendix, kidney, and ureter; they may also be used in operations on the biliary tract, the spleen, and the pancreas.

The Midline Incision.—Incisions in the midline have many advantages. They do not divide any of the nerves supplying the abdominal muscles and they are relatively bloodless. There is no separation of tissue planes, and no division of muscle-fibres; and the wound can rapidly be extended above or below the umbilicus. Above the umbilicus (Fig. 140) the median incision divides skin, fat, and the dense aponeurosis of the linea alba; below the umbilicus (Fig. 140), after the aponeurosis has been divided, the recti muscles are usually seen in close contact, and must be separated by dissection. The transversalis fascia is not always recognizable as a separate layer; it is intimately associated with the parietal peritoneum and should be divided with it.

If it is necessary to prolong the incision beyond the umbilicus, the knife may be carried round one side of it, or the whole umbilical cicatrix may be excised, but no harm results from cutting through the umbilicus in the midline

The midline incision above the umbilicus affords rapid and easy access to the stomach and the upper abdominal area; below the umbilicus, to the pelvic basin and its contents.

The abdominal wall is repaired in two layers, the first tier of sutures uniting peritoneum and transversalis fascia, the second the linea alba.

The *paramedian incision* is generally held to leave a stronger scar and is more popular on that account. The skin incision should not be placed more than 2·5 cm. (1 in.) from the midline, as otherwise the terminal part of the intercostal nerve trunk may be divided as it lies behind the rectus muscle (Fig. 140). In this event the inner

part of the muscle is paralysed, and bulges on the inner side of the scar The anterior layer of the rectus sheath is split in the line of the skin incision; the fibres of the rectus muscle may be separated in their long axis by blunt dissection or the whole muscle may be

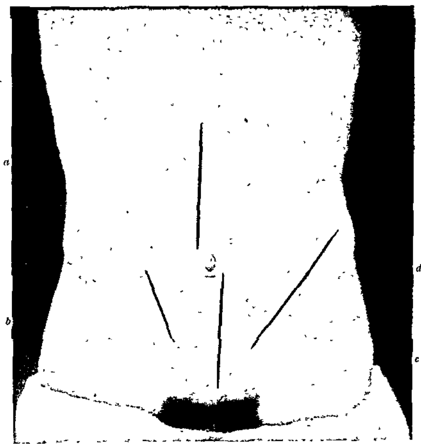


FIG 140 Abdominal Incisions.

Ureter,

mobilized and displaced laterally, and finally the posterior layer of the sheath, the transversalis fascia, and the peritoneum are picked up together in forceps and cut in the line of the incision.

Closure is accomplished by two layers of stitches The deeper row includes the peritoneum and posterior sheath in the upper part of the abdomen; below the linea semicircularis, where the posterior layer of the sheath is absent, the peritoneal suture should take a bite of the deep surface of the rectus muscle itself The muscle is allowed to slip back into place, and the anterior sheath accurately sutured.

The paramedian incision is used as an alternative to the midline incision: it gives better access to the structures in the supero-lateral quadrants of the abdomen, notably to the spleen, the duodenum, and the biliary passages.



FIG. 141. Abdominal Incisions.

a Right Subcostal (Kocher) for exposure of Biliary Passages.
b. Right Oblique Lumbar for exposure of Kidney.

Lateral Incisions.—A line from immediately below the tip of the tenth costal cartilage to the umbilicus represents the course of the tenth intercostal nerve. Lateral incisions immediately above and below the level of the umbilicus should be made parallel to this; above the umbilicus the nerves are more horizontally disposed, and transverse or near-transverse are safer than oblique incisions. An exception to the rule that lateral incisions should run parallel to the

nerves is often made in the case of operations on the biliary passages, for which many surgeons favour the subcostal incision of Kocher.

In the standard oblique or transverse incisions, the oblique and transverse muscles may be divided in the line of the skin incision or as an alternative the individual muscles may be separated in the line of their fibres—the so-called *gridiron method*. When the original wound requires to be extended anteriorly, the anterior rectus sheath is split to the linea alba, the rectus is mobilized and drawn medially—or else transected—and the posterior layer of the sheath divided to the midline.

The *subcostal incision* begins in the midline and runs laterally 2·5 cm. (1 in) below and parallel to the costal margin (Fig 14*a*) The muscles, including the rectus and the rectus sheath, are divided in the same line; the ninth intercostal nerve is severed, but the eighth and the tenth nerves should be identified as they course forwards between the internal oblique and the transverse muscles, and be carefully preserved and retracted.

Opening the Peritoneum.—As soon as the muscular layers of the abdominal wall have been divided, the wound edges should be draped with small towels which are secured to the skin by special forceps or by towel clips. These towels prevent contamination of the intra-abdominal contents by organisms from the skin, which remains bacteriologically 'safe' for only about thirty minutes after cleansing and superficial sterilization. The towels should be wrung out in warm saline to prevent drying of the tissues, and to avoid abrading the peritoneal coat of extruded intestine. The peritoneum is opened thus a small fold is pinched up with untoothed forceps, and as it is lifted upwards it is gently shaken to dislodge any structure adherent to its deep surface; the fold is then transferred to the grasp of a haemostat, and alongside it a second fold is picked up in the dissecting forceps. A small nick is then made between the two pairs of forceps, the scalpel being held more or less horizontally, and this is enlarged sufficiently to allow the surgeon to introduce his index and middle fingers into the abdomen. The fingers are employed to lift the peritoneum well forward so that the incision can be completed by cutting between them without danger to the bowel.

The presence of adhesions from previous operations may make it difficult to effect an entrance to the peritoneal cavity. In this event the adhesions at a selected point should be divided between forceps over a sufficient length to allow of the introduction of a small retractor. If the abdominal wall is now strongly lifted up, the remaining adhesions are put on the stretch, and it is usually possible to define the exact line of original adherence. If this is still not sufficiently clear, the intestine may be gently pushed away from the

retracted abdominal wall by the hand of an assistant. The line of original adhesion is usually bloodless and separation can be effected quickly and without danger.

Exposure and Mobilization of Viscera.—As soon as the abdomen is opened, an adequate survey of the parts immediately concerned must be carried out, and, if necessary, a rapid examination made of the other viscera. The exact nature of the operative procedure having then been determined, the appropriate viscus is withdrawn from the abdominal cavity or isolated. If the peritoneal cavity contains blood or fluid, it may be necessary to cleanse it before a proper inspection is possible. This is most easily done by suction, and a suction apparatus should be available for every abdominal operation. A less effective alternative is to mop up the fluid in the various peritoneal recesses with large moist gauze swabs. The complete removal of intraperitoneal blood is not necessary, and the duration of such emergency operations as that for ruptured ectopic pregnancy should not be delayed for the purpose: the blood which is left behind does not appear to cause subsequent trouble.

In operations in which stomach or intestine has to be opened, it is particularly important to avoid soiling of the peritoneum; the risk is greatly diminished if the viscus can be delivered on to the abdominal wall where it can be surrounded with large swabs wrung out in warm saline to prevent contamination of the wound in the parietes or of the towels protecting the skin edges. A viscus withdrawn from the abdomen quickly becomes dry and cold, and it must therefore be kept moist by frequent wiping with hot saline swabs.

In operations for obstruction of the small bowel in which the cause is obscure, the intestine may be systematically withdrawn until the lesion is discovered. The extruded bowel is completely covered with hot saline towels which are changed frequently. This procedure —*evisceration*—although sometimes condemned, is in fact quicker and less traumatizing than are groping attempts to pick up and trace a collapsed loop to the point of obstruction, its disadvantages are largely offset by the better anaesthetic methods now employed.

When the viscus cannot be withdrawn, it should be isolated by gently packing off the mobile viscera surrounding it with pads or rolls of gauze, and to prevent the risk of the packs being accidentally left inside at the end of the operation a piece of broad tape should be firmly stitched to the end and secured with artery forceps once the pack is in position. In introducing such packs care must be taken that the delicate endothelium of the peritoneum, and particularly that of the parietal peritoneum, is not abraded. The pack should therefore be slipped down the hollow of the hand and then gently placed in the desired position (Fig. 142). The packing should

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'fascia propria'; the fascia is often thickened in intra-abdominal disease, and not until it is freely divided can a plane of ready mobilization be defined.

Control of Bleeding.—Haemorrhage tends to obscure the operative field, and bleeding beneath the peritoneum and in the mesentery of the bowel may spread so rapidly and so diffusely that the accurate identification of structures becomes difficult. Intra-abdominal vessels should be securely ligated before division. In the case of the intestinal vessels this is most easily carried out by putting the mesentery on the stretch; the vessels can then be seen against the light and secured.

The Use of Clamps.—Two kinds of clamp are used in gastro-intestinal surgery: (1) *crushing clamps* or *enterotribes*, which are designed to compress the tissue within the grasp of the blades so that it is reduced to a thin band that can easily be secured by a ligature before being buried by superimposed rows of sutures. This form of clamp is used in such operations as enterectomy, in which the divided ends of the gut are to be completely occluded, and the continuity of the intestinal tract re-established by lateral anastomosis. (2) *Occluding* or *retention clamps* are employed to compress the bowel, to control bleeding from its wall when it is divided, and to prevent the escape of its contents. They are applied only to healthy intestine and for as short a time as possible; the blades may be covered with sheaths of rubber tubing to limit the injury inevitably inflicted on the bowel. Occlusion clamps are used in such operations as enterostomy, gastro-enterostomy, and end-to-end intestinal anastomosis, but in gastric anastomoses for peptic ulceration some hold that the use of clamps may predispose to the later development of gastro-jejunal ulceration.

Intestinal Sutures.—Wounds and incisions in the walls of the hollow viscera do not heal by union of the cut margins but by the coaptation and adhesion of the serous surfaces. All intestinal suturing, therefore, is designed to invert the wound edges and appose the peritoneal coats. In a few hours the wound is sealed off by fibrin; but the sutures must secure the united edges until fibrosis and permanent union occur. The stitches in the bowel wall should therefore be sufficiently deep to take a good bite of the tough submucous coat, otherwise they are liable to cut out if the intestine undergoes much distension afterwards. After resections it is important that the ends of the bowel be well nourished, and of a good colour, and that they should be freely movable. Rather than depart from this rule it is wiser to sacrifice further portions of the stomach or intestine.

The suture material may be fine catgut, linen, or silk; but in operations on the stomach most surgeons use only catgut, since an

be done systematically, and it is an advantage to employ two tiers of swabs 'Those first introduced are of large size, are well packed in position, and completely surround the field of operation. They remain unchanged throughout On top of this outer barrier of large

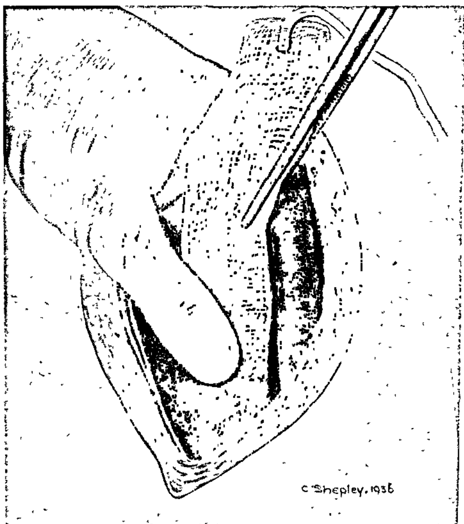


FIG 142 Insertion of Gauze Pack

swabs a layer of smaller ones is placed These are changed one by one as soon as soiled' (Moynihan)

colon, and the spleen The structures which must be divided are the peritoneum, and the underlying extraperitoneal cellular tissue—the

the occluding stitches with an omental tag from the neighbourhood.

The Lembert Stitch.—This is the classical method of intestinal suture and is used at some stage of virtually all operations on the gastro-intestinal tract.

About a quarter of an inch from the edge of the wound the needle pierces the serosa, the muscularis, and part of the submucosa, and, without entering the lumen of the bowel, it emerges again through the serosa close to the edge of the wound; on the opposite side it enters close to the edge of the wound and emerges a quarter of an inch farther away (Fig 143). The mucous membrane is not included, but when the stitch is tightened and the knot tied (Fig. 144), the mucous membrane disappears, being invaginated into the lumen of the bowel The bowel can be closed with greater rapidity and usually with equal security by a continuous rather than by a series of interrupted Lembert stitches; but in operations on the colon, where it is particularly important to limit tissue necrosis at the suture line, interrupted stitches are often preferred.

To control bleeding from the mucous and submucous coats, the Lembert suture is sometimes supplemented by an inner continuous suture passing through the mucosa, or all the coats—the *Czerny-Lembert suture* (Fig. 145).

The Connel Stitch.—This suture is usually employed to secure the primary closure and inversion of intestinal wound edges; the repair is then generally completed by a reinforcing continuous Lembert stitch which buries the original suture line. Starting from the peritoneal surface, the needle is carried through all the coats and then back again on the same side, thus making a 'loop on the mucosa'. Crossing to the opposite side of the wound, the same procedure is repeated, and when the stitch is pulled tight, the edges of the wound are inverted. It is important to stay close to the margins of the wound and not to [illegible]

suture circularly round an area of bowel, e g. the stump of the appendix, a perforation, or the divided end of a coil of intestine, so that, when it is tightened, the enclosed area is puckered in and the serous surfaces are brought into apposition (Fig. 146).

Drainage of Peritoneal Cavity.—The peritoneum is able to overcome all but the most serious infections. Tube drainage is consequently seldom necessary and never desirable; in any event the tube becomes isolated by adhesions within a few hours, after which it drains only the small area in its immediate vicinity. Nevertheless, a local drain may provide a vent not for pus already present, which

unabsorbable suture in the submucous coat may lead to ulceration of the mucosa, and to peptic ulceration. Fine round-bodied needles are employed; they may be either curved or straight at the convenience of the operator, and the points must be very sharp, to transfix the bowel wall easily. The minimum of injury is inflicted

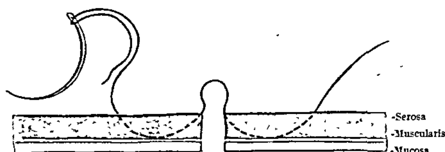


Fig. 143 Diagram of Lembert's Suture being introduced.

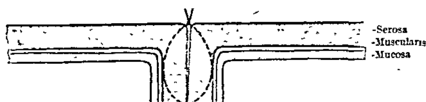


Fig. 144. Diagram of Lembert's Suture completed.

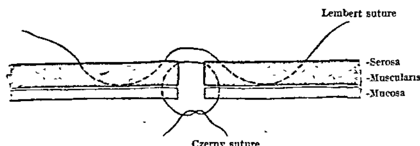


Fig 145. Diagram of Czerny–Lembert Suture

in the bowel wall if the suture material is machined to the needle, as in the various proprietary brands of atraumatic sutures. The stitches should avoid obvious blood-vessels, even at the sacrifice of symmetry, and they must not be drawn so tightly as to cause necrosis of the bowel wall and lead to leakage at the suture line. It is unnecessary to overlay the line of suture with omentum as a routine, if the technique is reliable, but in perforations of the stomach, the duodenum, or the colon, where the risk of stitch necrosis is considerable, it is generally wise to cover and reinforce

appendicitis, or operations in which the intestinal canal has been opened, such as intestinal resection and anastomosis.

The sulpha drugs may be introduced as a powder by insufflation or as a suspension in saline. Sulphanilamide, sulphathiazole, and sulphamethazine may be used with impunity; sulphapyridine, on the other hand, is a notable peritoneal irritant, and provokes the formation of adhesions. The intraperitoneal dose of sulphonamide should not exceed 10 grammes, as considerable absorption of the drug occurs.

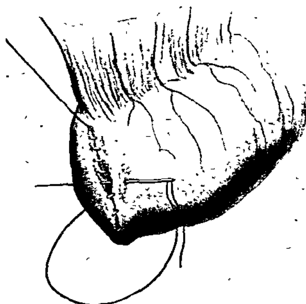


FIG 147. Closure of the Divided Small Intestine by two Tiers of Sutures.

There is little advantage in the local application of penicillin. An adequate bacteriostatic level can be ensured by systemic administration, provided the dose is sufficiently high—100,000 units three-hourly. Nevertheless, many operators make a practice of frosting the walls of an intraperitoneal abscess and the wound margins with a penicillin-sulphathiazole powder before closing the wound.

As no operation on the stomach or intestine can be regarded as strictly aseptic, gloves, protecting towels, and instruments should be changed before the wound in the parietes is closed.

Closure of the Abdominal Wound.—If incisional hernia is to be avoided, accurate repair of the wound is of first importance. Hernia is initiated by the escape of omentum between the edges of the [illegible]

[illegible] relaxation is necessary for this part of the closure; attempts

can be evacuated by suction or mopping, but for pus which may be formed subsequent to operation, when it has been impossible to eradicate the original focus of infection, or when the peritoneum has been grossly soiled. In practice, drainage is most often used in localized appendicular suppuration and in biliary operations in which a late accumulation of bile or blood may collect in the gall-bladder area. It is not usually required after operations on the stomach and intestine.

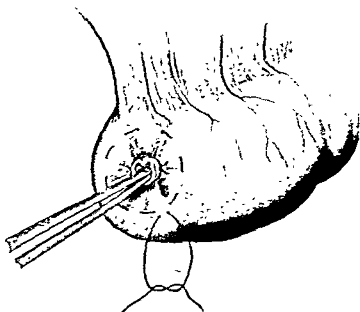


FIG. 146 Purse-string Suture introduced.

When drainage is decided upon, the drain should be introduced through a separate incision rather than through the laparotomy wound It should not be laid haphazardly amongst coils of intestine, but inserted into the definite space it is desired to drain. Rubber dam or corrugated rubber sheeting is preferable to rubber tubing, which may cause contact necrosis either of the bowel wall, when faecal fistula results or of blood-vessels, with consequent secondary haemorrhage. Although drainage of the peritoneal cavity is so seldom necessary, the superficial layers of the wound should be drained whenever there has been soiling by pus or intestinal contents.

Intraperitoneal Chemotherapy.—Modern chemotherapeutic agents—sulphonamides and penicillin—are now frequently employed to prevent, counter, or limit infection within the peritoneal cavity. Their value is hard to assess but there is sufficient evidence to warrant their use after operations for infective lesions such as

facilitate the insertion of the sutures, the edges of the peritoneum are picked up in a series of haemostats, and lifted away from the abdominal contents which may be kept in position by a gauze pack or a square of stiff but pliable indiarubber which is gradually withdrawn as the stitches are inserted. A round-bodied needle and strong catgut are used; the sutures may be continuous or interrupted, and they should be inserted parallel to and a short distance from the cut margin, so that when drawn tight the edges of the wound are

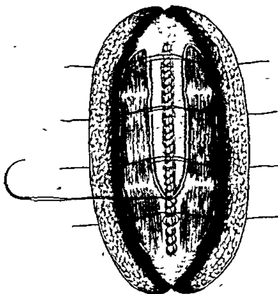


FIG 149 Rectus Sheath incised vertically and sutured in Middle Line. Skin Sutures inserted

everted. In vertical incisions, when the peritoneal suture is completed, a series of deep relaxation sutures of unabsorbable material—silk, silkworm gut, metallic wire—may be passed through the other layers of the wall on long bayonet-pointed needles. These stitches are left untied until the remainder of the repair is completed. In paramedian incisions the next tier of sutures approximates the edges of the wound in the anterior rectus sheath; a sharp-edged needle and stout catgut are used and the stitch is usually continuous.

In closing a midline incision above the umbilicus, particularly in stout subjects and in those with a narrow costal angle, additional security may be obtained by making a vertical incision into each rectus sheath 1·25 cm. ($\frac{1}{2}$ in.) from the midline. This frees the suture line from lateral pull and is an added safeguard against hernia (Fig. 149).

In the lateral oblique incision the several muscles are repaired in

to suture the peritoneum with the abdomen rigid or the patient straining lead to the cutting out of stitches and to the creation of new sites of potential herniation.

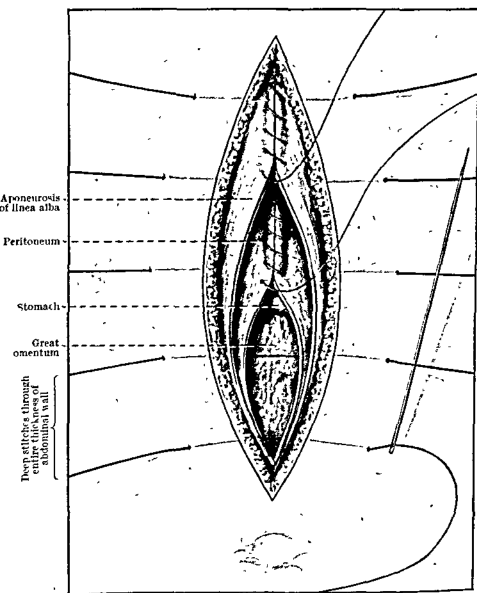


FIG. 148. Closure of Wound in Median Line above the Umbilicus.

The peritoneum is always sutured with the fascia transversalis, and in paramedian incisions also with the posterior sheath of the rectus; below the linea semicircularis, where the sheath is absent, the stitch should take a bite of the deep surface of the muscle. To

needs of the patient. Fluid may also be given subcutaneously or by rectum, and after an anaesthetic considerable quantities are absorbed by the latter route. The nature of the fluid is probably not important, and tap-water is as good as salt or glucose solutions, but its temperature should be adjusted to 105° F. and it must be introduced slowly. Rectal infusions must be avoided after operations on the colon, and large amounts are dangerous in cases of suppurative appendicitis or appendicular abscess, because of the risk of increasing the tension within the caecum to such a degree that faecal fistula results.

To relieve pain and restlessness, an opiate (morphine, gr. $\frac{1}{6}$–$\frac{1}{4}$, or omnopon gr. $\frac{1}{6}$–$\frac{1}{3}$, or heroin gr. $\frac{1}{12}$–$\frac{1}{6}$) should be given before the patient recovers from the anaesthetic.

Subsequent Management—Position in Bed.—After recovery of consciousness the patient may be allowed to assume any position that is comfortable. The sitting position is generally favoured, but pillows or supports behind the knees should be avoided as they lead to stasis and thrombosis in the deep veins of the calf, and favour the occurrence of pulmonary embolism. For the same reason frequent changes of posture, and some degree of activity, especially movements of the lower limbs, should be insisted on.

The Use of Sedatives.—It is usually necessary to prescribe a sedative on the first two or three nights following operation, and for this morphine is most reliable. It should not be given as a routine at stated hours, however, but only as it appears to be warranted by the patient's discomfort, and it should be dispensed with as soon as possible. The over-liberal use of morphia preparations, by tending to dry the bronchial secretion and diminish the cough reflex, favours the development of collapse of the lung by plugging of the bronchi.

Provision of Fluids.—An average-sized adult requires a daily intake of at least 3 litres (5 pints) of fluid to maintain a normal urinary output and to replace the fluid normally lost through the skin and lungs. After laparotomy patients are already in a state of negative balance, since during the operation and in the first few hours afterwards a considerable amount of fluid may be lost by sweating.

The Wound Dressing.—Unless inspection is indicated by the occurrence or persistence of pain after the first forty-eight hours, a clean laparotomy wound should not be dressed until the stitches are to be removed. Discomfort may be due to drag on the stitches by dressings caked with blood, or to stitches tied too tightly, or to the formation of a haematoma, or to sepsis. A haematoma should be evacuated by sinus forceps introduced between two adjacent stitches, or a stitch may be removed. In the presence of infection dressings should be changed frequently to prevent the wound being

layers; and since the incision lies in the line of pull of the muscles, the deep sutures may be omitted.

In all types of wound, and particularly in stout subjects, late stretching of the cutaneous scar can be lessened by suture of the superficial fascia; and the skin edges are then accurately approximated with metal clips, or by continuous suture or interrupted stitches of non-absorbable material such as silkworm gut or silk.

Finally the deep relaxation stitches are tied As they tend to cut into the skin if the abdomen becomes distended, the loops in contact with skin may be ensheathed in fine capillary rubber tubing, or they may be tied over a roll of gauze.

The *dressings* are best retained in position by means of overlapping strips of elastoplast or adhesive plaster which completely cover them. Further bandaging is not usually required, but if for any reason it is considered necessary, a many-tailed binder is preferable to a roller bandage, as it permits inspection of the wound with a minimum of disturbance to the patient; it may be prevented from slipping by bringing the two lowest 'tails' round the thighs and the two uppermost over the shoulders in the fashion of braces.

The bandage must not be tight, or else, by hindering the respiratory movements of the lower part of the chest, it will favour the development of pulmonary complications in addition to causing considerable discomfort It should be borne in mind that in the presence of abdominal distension even a loosely applied bandage may become tight and constricting, and frequent adjustments may be called for in the early post-operative days.

Post-operative Care.—*Immediate Management.*—It is often convenient to set aside a small ward adjacent to the theatre as a recovery room The bed to which the patient returns should be well warmed, but as a rule hot-water bottles should be removed before the patient is transferred to it, and the temperature of the room should not cause sweating and increased loss of fluids In most cases the patient should be placed in the horizontal position, with the head turned to one side to prevent aspiration of vomitus

When the operation has been extensive, or ill-borne, and the patient leaves the theatre in a state of 'surgical shock', special resuscitation measures may be demanded The foot of the bed is raised on blocks, and to maintain the body temperature, warmth must be applied by hot bottles, plentiful coverings, and a 'shock' cage. Coverings must not embarrass breathing, and as soon as the body temperature rises the heating agents are withdrawn or reduced before they induce sweating

Steps should be taken to restore fluid lost during the operation by intravenous infusion of saline, plasma, or blood according to the

generally preferred. On the evening of operation weak milkless tea, dilute fruit juice, or albumin water can be given. On the following day the diet should be largely liquid, but dry toast and jelly provide a welcome change from fluids and help to restore normal peristaltic activity.

By the third day a light diet may be started consisting of strained porridge, bread and butter, lightly boiled egg, cream soups, minced lamb, chicken or steamed fish, and custard or milk pudding. After the aperient has acted on the third day, there should be rapid progress towards a normal diet.

When post-operative shock, undue vomiting, or abdominal distension interferes with recovery, the usual dietetic régime may have to be interrupted. It is usually best to postpone or abandon attempts at feeding by mouth, and to resort to parenteral methods. Fluid and glucose can be supplied by this means for many days; but it is wise to administer plasma also to counteract protein loss.

Oral Hygiene.—This forms an important part of the after-care, more especially when it has been necessary to withhold fluids by mouth, in under-nourished subjects, and in those with pre-existing oral infection.

The mouth should be frequently rinsed with a weak solution of hydrogen peroxide and, as soon as possible, regular teeth-brushing is begun. A heavily furred tongue may be cleansed with swabs wrung out in borax and glycerine or in a solution of carbonate of soda, and the patient may be given chewing-gum or acid drops to stimulate salivation

Getting Up.—The duration of recumbency in uncomplicated abdominal operations varies from ten days in the case of small oblique wounds to fourteen to twenty days in the case of midline or paramedian wounds Earlier rising is sometimes advocated, but it does not hasten ultimate recovery. During the time in bed activity should be insisted on and systematic exercises of the abdominal and respiratory muscles carried out, preferably under the supervision of a trained physiotherapist.

A well-planned and adequately repaired incision does not normally require the artificial support of a surgical belt; but this may be advisable if there have been previous operations on the abdomen, and if the abdominal wall is fat and flabby.

Return to Work—For complete rehabilitation a few weeks' rest is needed after leaving hospital In deciding when work can be resumed, the nature of the employment and the patient's psychological outlook count as much as the nature of the operation, but as a general guide two to four weeks' convalescence should be advised after such operations as uncomplicated appendicectomy;

constantly bathed in discharge; the skin can to some extent be protected against the irritating effect of discharges—particularly faecal discharge—by sterile vaseline or a zinc-castor oil paste applied directly or on strips of lint. A solution of rubber in acetone also forms a useful protective medium.

Management of Drainage Tubes.—Drains which have been used simply to guard against the accumulation of blood in deep wounds should as a rule be shortened on the second or third day and removed altogether on the fourth day.

Deep intraperitoneal drainage tubes should generally be left longer *in situ*, they may be gradually shortened by 1·25 cm. (½ in) after the fourth day, and the tube may be removed daily for thorough cleaning and then reintroduced. A sterile safety-pin through the projecting part of the drain prevents its displacement into the abdominal cavity.

Tampons should be left undisturbed for five or six days; their removal is then usually easy, and not likely to provoke further bleeding

Care of the Bowels.—A certain amount of abdominal discomfort is usual after abdominal operations, it is due to the accumulation and movement of gas in the intestine, and is generally worse when there has been vigorous purgation before operation, or much handling of the bowel at operation. Gas pains may be relieved by the introduction of a rectal tube, or by a glycerine enema (2 oz each of glycerine and water)

An aperient should be administered on the morning and the third day following operation The nature of the laxative does not matter, castor oil (½ oz) or any other purgative that the patient is accustomed to may be prescribed Even in 'clean' abdominal cases the bowel function may prove difficult to restore, and the initial dose of aperient may need to be repeated, or to be supplemented by an enema, and it may be necessary to give small nightly doses to ensure daily evacuation for as long as the patient is confined to bed.

Post-operative Diet—The dietetic management following operation varies with the nature of the operation, and individual consideration may have to be given to the nutrition in such special cases as peritoneal infections and gastro-duodenal complaints In every case, however, it is desirable to restore a diet rich in protein as soon as possible, and it should be appreciated that after laparotomy a greater amount of protein is needed than in health, on account of the increased protein breakdown

After laparotomy nothing should be given by mouth until post-anaesthetic nausea or vomiting has stopped. Thereafter small quantities (2–4 oz) of fluid may be allowed, and cold water is

The clinical features are not characteristic, and the condition is often complicated by infection of the peritoneum. At first, all that is noticed is that the patient is not well; he is restless, complains of tightness and pain in the abdominal wall, which is often so exquisitely tender that he is afraid of being touched; there is some nausea and a raised pulse-rate; the temperature is generally raised, but in grave infections it may be subnormal. When the dressing is removed, the skin may show a dusky mottling and the abdomen is swollen and tight; if one or two stitches are cut and the wound edges separated, there escapes an offensive, sero-purulent, mud-coloured discharge, often with bubbles of gas.

The toxaemia varies greatly in degree: in fatal cases the skin becomes cold and clammy and the pulse rapid and thready; in the majority of cases the course is like that seen in acute gangrenous appendicitis attended by infection of the abdominal wall.

The wound should be widely opened by removal of all the sutures; it is irrigated gently with hydrogen peroxide and covered with a proflavine dressing. Regular hot fomentations are applied to the whole abdominal wall, and intensive penicillin and sulphatherapy instituted. When the toxaemia is intense, fluids should be administered parenterally The antiserum of *Bacillus welchii* is sometimes advocated, but there is no evidence that it is beneficial.

Disruption of the Wound.—'Burst abdomen' is one of the gravest complications of laparotomy, and carries a mortality rate of close on 40 per cent. It occurs after midline or paramedian incisions only, and appears to be due to a combination of causes The nutritional status of the patient is important, and rupture tends to occur in elderly debilitated and cachectic subjects. Undue strain on the wound —especially after operations for inflammatory conditions—may also be an important factor: thus cough, abdominal distension, and persistent vomiting are important predisposing conditions.

When the rupture is complete, coils of small intestine escape into the dressings, but this is often preceded by giving way of the deeper layers. In the latter event the wound bulges, and the skin stitches appear partially buried, the swelling is resonant on percussion, and there is usually a copious blood-stained discharge.

The accident is generally accompanied by pain, and a sense of something giving way, and the patient's general condition rapidly worsens. When the diagnosis is confirmed by inspection, the protruded bowel should be covered with a sterile towel and the patient taken to the operating theatre. The coils of intestine are gently washed with saline, replaced, and held in position by a moist pack while the wound edges are approximated. To facilitate the introduction of the sutures, traction stitches of stout silk are introduced

and two to three months after such major procedures as resection of the stomach and operations on the gall-bladder and bile-ducts.

Complications after Abdominal Operations.—*Post-operative Fever.*—Even after clean operations the temperature may be raised one or two degrees for the first seventy-two hours; this is due to absorption of blood and products of tissue damage at the site of the wound Fever persisting beyond this initial period may be of serious import, and its cause must be immediately investigated. The commonest sources of raised temperature are sepsis in the wound or within the peritoneal cavity, chest complications, and thrombosis and thrombo-embolism. The temptation must be resisted to administer haphazardly sulphonamide and penicillin, and to neglect the diagnostic problem.

Wound Complications.—Inspection of the wound should be the first step. A superficial haematoma, even when uninfected, may give rise to mild pyrexia, it should be evacuated by sinus forceps introduced into it between adjacent stitches The slightest form of established wound sepsis is a localized suppuration in relation to one of the stitches; systemic effects are few, and such 'stitch abscesses' clear up quickly after removal of the stitch.

Diffuse superficial infection—'cellulitis' of the wound—gives rise to more marked general effects. the pulse-rate is raised as well as the temperature, and there is usually leucocytosis. The wound is tender to touch, and looks red and swollen, the stitches appear to be so tight that they are practically buried in the oedematous skin. In such cases one or two stitches should be removed, and the wound edges gently pressed apart to afford exit to any pus; and regular hot fomentations should be applied over a thin gauze dressing Chemotherapy by systemic penicillin and oral sulphonamide should be instituted at once

When it has been necessary to remove many of the sutures and the wound tends to gape widely, secondary suture may be carried out when the infection has subsided.

Anaerobic infection of the abdominal wound may complicate operations in which the lumen of the bowel is opened or in which a leakage of intestinal contents occurs. This risk is extremely small in appendicectomy and small bowel resections, but in resections and anastomosis of the colon it is far from negligible

The infection involves the subcutaneous cellular tissue of the abdominal wall, but it may extend to the areolar tissue planes between the muscles, or even to that between the transversalis fascia and the peritoneum The tissue acquires a greyish-green colour, and yields a foul-smelling, mud-coloured discharge, considerable portions of tissue may come away as sloughs.

intestinal obstruction, but when localized suppuration occurs, the abscess must be evacuated in an appropriate manner.

Persistent Vomiting.—After laparotomy this may be of serious import, and usually indicates the presence of acute dilatation of the stomach or of intestinal obstruction. Vomiting due to the anaesthetic alone is now very rare, and generally ceases when the patient has fully recovered consciousness, but in highly nervous subjects it may persist for some days. In children vomiting may be a sign of acidosis, while in some individuals sickness is an evidence of idiosyncrasy to morphine.

When it is not due to a serious intra-abdominal cause, the vomiting may be controlled by change of sedative, the administration of glucose, frequent changes of position in bed, by the administration of sodium bicarbonate (1 drachm to a tumbler of warm water), or by sips of champagne. Should it fail to respond to such simple measures, resort may be had to gastric lavage, or to suction and parenteral fluid therapy.

Post-operative Haematemesis is another rare type of persistent vomiting in which toxaemia is responsible for the haemorrhage from the gastric mucosa; the blood is darkened or even blackened by the digestive juices, and can often be seen on the clothing and bed linen when vomiting has occurred without preliminary retching or other warning. Gastric lavage and suction along with the provision of intravenous fluids are the measures which generally control it.

Acute Dilatation of the Stomach.—This urgent and serious complication may occur in the first few days after laparotomy. There is enormous distension of the stomach, due most likely to initial paralysis of the gastric muscle followed by obstruction of the third part of the duodenum by the mesentery of the small intestine. Persistent and effortless vomiting of large quantities of thin greenish-brown fluid leads to rapid dehydration. The fluid consists of the gastric, duodenal, pancreatic, and biliary secretions, and loss of the contained chlorides is quickly followed by alkalosis. The upper part of the abdomen becomes grossly distended, and respiratory embarrassment and hiccough are commonly associated. The pulse-rate is raised and continues to rise; and if the complication is not recognized, distension becomes generalized, the patient becomes increasingly weak, dehydrated, and toxic, the respirations weaker and shallow, and death results in from thirty-six to forty-eight hours.

A suspected diagnosis is easily confirmed by the passage of a duodenal tube, which will withdraw a large quantity of fluid. Dilatation of the stomach can be distinguished from peritonitis by the absence of fever, the typically upper abdominal distension, and the speedy relief from the passage of a tube; in intestinal obstruction

at each end of the wound beyond the original incision; they are used to lift up the abdominal wound while stitches of strong silk, silkworm gut, or stainless steel or silver wire are carried through the whole thickness of the abdominal wall on each side at intervals of 1·25 cm. (½ in.); each is tied in turn and used as a retractor, and the pack is withdrawn before the last stitch is secured.

If for any reason resuture of the wound is impracticable or inadvisable, the retention pack should be left in place and the abdominal wound closed as far as possible with bands of elastoplast strapping.

Post-operative Peritonitis.—Generalized infection of the peritoneum after laparotomy is a complication of the gravest significance. Excluding those cases in which it occurs as a spread from an obvious suppurating focus, and those rare cases of fulminating streptococcal infection introduced from without, post-operative peritonitis is generally a sequel to contamination by bowel contents either at the time of operation or later from leakage at an intestinal suture line. The risk can to some extent be minimized by pre-operative preparation with a locally acting sulphonamide such as succinylsulphathiazole, and by the use of sulphonamide applied locally.

Post-operative peritonitis is not attended by the classical features of the disease. Symptoms are notably absent till a late stage, and in the first instance attention is drawn to the possibility of peritoneal infection by persistent elevation of the pulse rate and a raised temperature. The tongue is heavily furred, and the patient wears an alert, bright-eyed, intense expression. Vomiting begins later, and the eventual picture is that of intestinal obstruction, which is usually the cause of death.

At first there may be little to see on inspection of the abdominal wound, unless there is an accompanying wound infection; but later there is generalized distension and generalized tenderness. Rigidity of the abdominal muscles is hardly ever present.

When the patient is recovering, watch must be kept for the development of *residual abscesses*, especially in the neighbourhood of the wound, in the pouch of Douglas, or in the subdiaphragmatic spaces. An abscess in the depths of the wound causes deep local tenderness, and it is usually possible to palpate an area of brawny induration, which gradually localizes and softens. A pelvic abscess may give rise to diarrhoea and rectal tenesmus, and to frequency and urgency of micturition. A subdiaphragmatic abscess gives rise to pain in the loin and beneath the lower ribs, often referred to the point of the shoulder. The respiratory movement of the lower part of the chest is diminished and the area of liver dullness increased.

The treatment of generalized peritonitis is similar to that for

intestinal obstruction, but when localized suppuration occurs, the abscess must be evacuated in an appropriate manner.

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distension begins centrally, and the relief from suction is more delayed. Treatment is by continuous suction and parenteral fluid replacement, and an attempt is made to relieve the duodenal obstruction by raising the foot of the bed and turning the patient on to his face or on his right side.

Abdominal Distension.—A certain amount of abdominal distension is not uncommon after laparotomy, in association with 'gas pains'. Both are usually relieved by flatus tube and flatus enema.

Occasionally distension becomes so exaggerated that it induces marked discomfort; it may then hamper respiration and favour collapse of the lung, or else by interfering with the venous drainage from the limbs it may predispose to thrombosis and pulmonary embolism.

The bandages should be loosened at once, a flatus tube inserted, and a hot fomentation applied over the dressing to the whole abdominal wall. If there is not speedy relief, the use of drugs must be considered. Morphia has the virtue of ensuring comfort or sleep, and there is evidence that it improves the tone of the intestinal muscle. It must not be used so liberally or so often as to mask the onset of a true obstruction. For this reason many prefer more effective stimulants; an intravenous injection of 50 c.c. of hypertonic saline (15 per cent.) may be used, or prostigmin (1 c.c.), pitressin (1 c.c.), or pituitrin (1 c.c.) with eserine (gr. 1/100) should be followed in half an hour by a flatus enema. In extreme cases which do not respond to these measures, a spinal anaesthetic may afford complete relief.

Post-operative Intestinal Obstruction.—The cardinal signs of obstruction, as opposed to simple distension, are repeated vomiting associated with absolute constipation. The most common form of obstruction is the so-called *paralytic ileus* which occurs in association with peritonitis. The abdomen is distended and drum-like; there may be a sense of discomfort or tightness, but pain is absent, and on auscultation the abdomen is silent. Vomiting begins by the ejection of mouthfuls of fluid, usually without nausea, and the vomit gradually becomes faecal. The patient is alertly conscious, but becomes rapidly hollow-eyed and pinched as a result of dehydration. Treatment consists in the immediate institution of continuous gastric or intestinal suction combined with the intravenous administration of fluids. Penicillin and sulphonamides should be given, since peritonitis is usually present.

Suction should be continued until only clear fluid is being withdrawn. It is not necessary to withhold fluids by mouth whilst it is in progress, in fact, oral fluids keep the mouth moist and clean, and they constitute a kind of gastric lavage.

When the fluid is clear and the general condition of the patient

restored, suction may be discontinued. The tube is clamped, but left in place, and if vomiting does not recur, an aperient may be administered through it before it is withdrawn.

Mechanical obstruction following operation is due to the formation of adhesions, bands, or kinks. It may consist of a simple obstruction of the lumen, or of a volvulus or internal strangulation, and it can be distinguished from the paralytic variety of ileus by its later onset (4–7 days), by the occurrence of colicky abdominal pain, and by noisy peristalsis on auscultation. Distension is generalized, and peristalsis may be visible or palpable through the abdominal wall.

It is important to recognize the mechanical element in the obstruction since attempts to drain the intestine by gastric intubation are not likely to succeed. If an enema at the outset followed by another in two hours is unsuccessful, the abdomen should be reopened and the cause sought and dealt with.

Hiccough.—Not infrequently this troublesome complication is encountered after laparotomy. As a rule it is transient and of little significance; then it may be simply an hysterical phenomenon in nervous subjects. In other cases the twitching of the diaphragm is reflex, and a sequel to irritation of the vagal, splanchnic, or pelvic nerve endings. Thus accumulation of old blood in the stomach, distension of the colon, and reversed peristalsis may each induce it. Of more serious import is the refractory form of hiccough which is associated with peritonitis, post-operative obstruction of the stomach or intestine, and, in older subjects, impending renal failure. Then it is a sign of grave prognostic significance: it leads to increasing exhaustion and may itself precipitate or cause death.

Mild cases generally respond to sedatives, but the dose may with advantage be increased or administered more frequently (e.g. morphine, gr. $\frac{1}{3}$, 3-hourly). At the same time the abdominal bandages should be loosened, and if a drainage tube has been left in, a slight change in its position may sometimes give relief. Drinks of ice-cold water, drunk while holding the breath, or the swallowing of fragments of chopped ice, inhalation of a CO_2–O_2 mixture (or rebreathing into a paper bag held tightly round the nose and mouth) may terminate the attack.

In very extreme cases such as those associated with peritonitis, when the hiccough is leading to grave exhaustion, it may be necessary under local anaesthesia to expose and paralyse the phrenic nerves.

Post-operative Pulmonary Complications—All forms of pulmonary complications occur after laparotomy, but two—collapse of the lung and pulmonary embolism—are of special importance in view of their frequency and the possibilities of prevention and treatment.

Bronchitis and broncho-pneumonia usually occur within the first few days; the usual evidence is present and treatment follows the generally accepted lines

Collapse of the lung is due to obstruction of a bronchus by excessive or inspissated secretion. The secretion is usually more viscid than normal, and its expulsion is hindered by the limitation of chest movement consequent upon a painful wound in the abdominal wall, possibly accentuated by a tight abdominal binder or bandage. The excessive use of sedative drugs such as morphine also tends to diminish the cough reflex

The collapse becomes apparent on the second or third day; the onset is usually acute, with sudden breathlessness and cyanosis, and raised temperature and pulse-rate Examination will reveal immobility of the affected side of the chest and some displacement of the heart, together with absence of breath sounds and marked dullness on percussion These signs may suddenly disappear if the plug of mucus is expelled by coughing Occasionally, however, the lung does not expand, but becomes the site of a pneumonitis with consequently delayed recovery.

Most cases clear up spontaneously in two to three days, but recovery may be accelerated by hyperventilation of the lungs with a CO_2O_2 mixture, or by inducing expulsion of the mucus by postural drainage and coughing (the patient lies on the unaffected side, with the foot of the bed raised) Morphine should be used sparingly, but an expectorant mixture should be prescribed, and protective chemotherapy instituted

If improvement does not quickly take place, bronchoscopic aspiration of the bronchial mucus may be carried out by one skilled in the operation.

Pulmonary embolism is a sequel to thrombosis, usually in the deep veins of the calf, less commonly in the pelvic veins The occurrence of the primary thrombosis may be manifested by slight elevation of temperature or pulse-rate and by complaint of pain in the calf or in the popliteal region. Tenderness of the calf muscles may be associated with some oedema of the ankle and limited dorsiflexion. Less often the thrombosis is so extensive that there is complete obstruction, and the clot extends into the femoral vein, with the production of phlegmasia alba dolens This variety of thrombosis carries little or no liability to pulmonary embolism.

In some cases the thrombosis is not recognized, and chest symptoms may be the first evidence that it has occurred.

Detachment of a small embolus causes a small pulmonary infarct with a patch of pleurisy overlying it. There is sudden pain which may be substernal or in the lower part of the chest. The pain may

be accompanied by faintness and dyspnoea, and after some hours by slight pyrexia. When the infarction is larger, there may be more obvious shock associated with some cyanosis, increased pulse-rate, and fever; and after twenty-four hours the patient may cough up sputum stained with bright red blood.

A small embolism may be followed by others, not necessarily in the same lung, and sometimes after a succession of minor infarctions a massive embolus lodges in the main branches of the pulmonary artery. In this event, which may also occur without previous warning, there is sudden and extreme respiratory embarrassment and profound shock, and death may occur in a matter of minutes.

The occurrence of thrombosis in the calf veins is favoured by immobility in bed immediately before or after operation, and by the use of a pillow or a 'donkey' behind the knees. Active exercises of the lower limbs should be part of the after-care for all abdominal operations, and the routine and prolonged use of such sitting positions as the Fowler position should be avoided.

When thrombosis or pulmonary infarction has occurred, treatment by anti-coagulant remedies should be begun forthwith, with the object of prolonging the bleeding time to fifteen minutes. This objective can usually be secured by 75–100 mg of heparin every six hours. Movements of the lower limbs should be encouraged during the heparin treatment, which will usually have to be continued for several days. Chemotherapy should be instituted to diminish the risk of supervening pulmonary infection, and morphia and hot applications to the chest are used to control the distressing pain of the accompanying pleurisy.

After one or more minor pulmonary infarcts, an attempt may be made to prevent sudden massive embolism by ligation of the femoral vein, and on a number of occasions a massive clot has been extracted from the pulmonary artery by Trendelenburg's method.

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operative procedure. The inhibition of the abdominal muscles, and possibly trauma to the pelvic nerves in the course of manipulations in the lower abdomen, are important factors, but in many cases there is a pronounced psychic basis and in some men a genuine inability to micturate in the recumbent position. In elderly men the possibility of a pre-existing prostatic enlargement has to be taken into consideration.

It is not uncommon for no urine to be passed for twenty-four hours after operation This need not occasion anxiety unless there is pain or distension, but due allowance must be made for the possible effect of basal narcosis and sedatives in abolishing pain. Failure to pass

any urine after the first day should be treated as retention, and the passage of small quantities at frequent intervals should raise the suspicion of retention with overflow incontinence.

Retention may be relieved by simple means: reassurance in the nervous, hot applications to the lower abdomen and perineum, or the assumption of a level, semi-prone or sitting position. If the nature of the operation does not contra-indicate it, the male patient may even be allowed to stand alongside the bed. If the abdomen is distended with gas, a flatus enema may lead simultaneously to relief of the abdominal distension and of bladder retention. Bladder-stimulating drugs (doryl, moryl (1 c.c.), carbachol (1 c.c.), camodil (1 c.c.)) may be employed if these simple measures fail, but they must not be used until organic obstruction is excluded. In the latter event, and when the other remedies are unsuccessful, the urine should be withdrawn by means of a small catheter (size 6 or 8) passed with full aseptic precautions. Further catheterization should be carried out as indicated, until normal micturition is established, if it has to be repeated on several occasions, especially in women, a small quantity (20 c.c.) of an antiseptic solution (e.g. argyrol 10 per cent.) should be instilled to prevent cystitis. Fluids should be given in abundance in all cases, and especially when there is organic urinary obstruction, and full courses of sulphadiazine, sulphathiazole, or sulphamethazine.

Post-operative Parotitis.—Pyogenic infection of the parotid gland is a rare but serious complication of laparotomy, especially in previously dehydrated subjects, in those with established oral sepsis, and in those in whom it is necessary to withhold fluids by mouth. It gives rise to considerable toxaemia, and pain and fever are generally prominent.

The incidence of parotitis may be reduced by eliminating foci of intra-oral infection before operation, and by a scrupulous routine of oral hygiene after operation. When pain in the cheek, jaw, or ear indicates that infection has occurred, it may be possible to prevent suppuration by energetic chemotherapy, or by a single application of X-rays. Heat may be applied to the gland by means of antiphlogistine or hot fomentations, and regular mouth washes prescribed.

If the swelling and pain do not subside in three days, the tension in the gland should be relieved by a small incision, through the skin only, over the most prominent part of the swelling, or behind the angle of the jaw. Sinus forceps are then passed through the capsule to let out any pus, and drainage is ensured by the introduction of a slip of dental rubber.

J. B.

CHAPTER XXII

OPERATIONS ON THE STOMACH AND DUODENUM

Anatomy. Physiology. Gastrotomy. Gastrostomy. Congenital Hypertrophic Pyloric Stenosis. Gastric Ulcer. Duodenal Ulcer. Posterior Gastro-enterostomy. Anterior Gastro-enterostomy. Anastomotic Ulcer. Duodenal Ileus. Gastric Carcinoma. Partial Gastrectomy. Total Gastrectomy.

Anatomy.—The position of the stomach varies with the attitude of the patient, the quantity of food or gas it contains, the tone of the abdominal muscles, the degree of distension of the transverse colon and small bowel, and with the emotional state.

The *cardiac orifice* lies about 10 cm. (4 in.) deep to a point on the left seventh costal cartilage 2 5 cm. (1 in.) from the sternum. The expanded upper part of the stomach above the level of the oesophageal opening is the fundus, which lies under the left cupola of the diaphragm. In the partly filled stomach in the erect attitude the body extends downwards to the umbilical plane or lower, and may be demarcated from the distal part by the angular notch on the lesser curvature. The distal part, consisting of the pyloric antrum and the pyloric canal, passes upwards and to the right to end at the pylorus, which is situated a little to the right of the midline and half-way between the xiphoid process and the umbilicus. In the erect attitude the outlet of the stomach may fall 2 5 cm. (1 in.) or so, and when the stomach is distended it may pass well to the right of the midline The pyloro-duodenal junction can be identified by subserous veins passing from the upper and lower borders (W. J. Mayo), and also because the duodenum is much thinner-walled than the pylorus.

The stomach possesses two curvatures and two surfaces. From the lesser curvature and the first 2 5 cm. (1 in) of the duodenum, the lesser omentum extends to the hilum of the liver. To the greater curvature is attached the anterior layer of the greater omentum, and on the left, and continuous with the greater omentum, is the gastro-splenic ligament passing to the hilum of the spleen The anterior surface of the stomach lies within the greater peritoneal cavity, whereas the posterior surface of the stomach forms part of the anterior wall of the lesser sac.

The duodenum is attached to the posterior abdominal wall. It forms a spiral horseshoe curve, open to the left and above, in the concavity of which lies the head of the pancreas. The first portion is only 5 cm. (2 in.) long and runs backwards, upwards, and to the right, behind and below the quadrate lobe of the liver; it lies to the right and in front of the portal vein, gastro-duodenal artery, and common bile-duct. It bends round beneath the caudate process of the liver into the second or descending portion, which runs downwards in front of the medial margin of the right kidney and behind the gall-bladder and transverse colon. In the erect posture the junction of the second and third portions—the inferior duodenal flexure—is the lowest part of the duodenum, and it is one of the sites at which foreign bodies may be impacted. The third or horizontal portion passes to the left and in front of the body of the third or fourth lumbar vertebra and of the vena cava, then turns abruptly upwards in front of the aorta as the fourth [illegible]
crossed by the superior mese [illegible]
The fourth portion is 2 5 cm. [illegible]
of the second lumbar vertebra, where, overlapped by the stomach, it bends

sharply forward to join the jejunum. The duodeno-jejunal junction is attached to the left crus of the diaphragm by means of the suspensory muscle of the duodenum. Near it there is a pouch of peritoneum—the duodeno-jejunal fossa—into which intestine may be protruded.

The common bile-duct penetrates the wall of the second or descending portion of the duodenum at the junction of its left and posterior walls just below its middle, and opens along with the pancreatic duct (duct of Wirsung), either close to the duct or by an opening common to both ducts. The accessory pancreatic duct (duct of Santorini) opens above and a little in front of this.

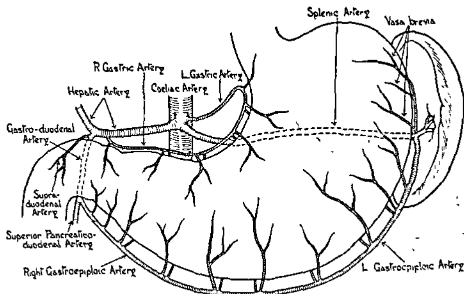


Fig 150 Arterial Supply of the Stomach.

The arterial supply of the stomach (Fig 150) is derived either directly or indirectly from the coeliac axis. The left gastric artery passes upwards and to the left and reaches the stomach near the oesophageal opening. It courses downwards along the lesser curvature between the layers of the gastro-hepatic omentum. The right gastric artery arises from the hepatic artery and usually is small. It passes along the lesser curvature and becomes continuous with the left gastric artery. The right gastro-epiploic artery, a branch of the gastro-duodenal artery, arises near the lower border of the first part of the duodenum. It courses to the left between the layers of the great omentum, a short distance from the greater curvature of the stomach, and becomes continuous with the left gastro-epiploic artery. The latter arises from the splenic artery near the hilum of the spleen Vasa brevia from the splenic artery and its terminal branches extend along the gastrosplenic ligament to supply the left part of the body and fundus of the stomach From the vascular arcades along the curvatures of the stomach numerous branches pass at right angles to the long axis of the stomach before breaking up into terminal branches The veins correspond to the arteries and empty into the splenic, superior mesenteric, and portal veins.

The first part of the duodenum is supplied by the supraduodenal branch of the gastro-duodenal artery, and by branches from the superior pancreatico-duodenal on its lower border. As the anastomosis in the first part of the

duodenum is not free, in gastrectomy it is wiser to remove most of it, the duodenal stump being invaginated into a part which has a reliable blood-supply from encircling branches of the pancreatico-duodenal artery.

The lymph vessels (Fig 151) of the stomach are closely associated with the blood-

coeliac axis In the region of the vasa brevia the lymphatics drain into a group of nodes in the gastro-splenic ligament and thence to a chain of nodes along the

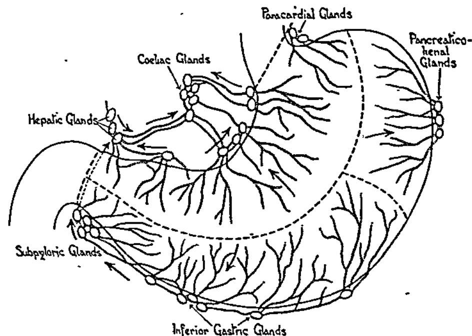


Fig 151. Lymphatic Drainage of Stomach showing direction of flow, and main Lymph Glands.

upper border of the pancreas. The inferior gastric nodes lie along the remainder of the greater curvature. A cluster of nodes on the head of the pancreas immediately below the first part of the duodenum and pylorus is known as the sub-pyloric group. The main lymph vessels draining the inferior gastric and sub-pyloric nodes pass upwards between the head of the pancreas and first part of the duodenum After being joined by lymph vessels descending from the liver in the right border of the gastro-hepatic omentum and lymph vessels associated with the right gastric artery, the main vessels follow the hepatic artery to the coeliac nodes.

Physiology.—The chief function of the stomach is to receive food and, after reducing it to a suitable consistence, to pass it in small amounts into the duodenum The reduction of food into *chyme* is effected partly by the digestive action of pepsin and hydrochloric acid secreted by glands in the fundus and body of the stomach, and partly by the mechanical action of the muscular pyloric segment. Gastric secretion is largely under the control of the vagus nerves. The distal end of the stomach produces a hormone which stimulates a flow of hydrochloric acid and pepsin. Contraction of the musculature of the

stomach is mediated by the vagi, the pylorus is under the control of sympathetic fibres derived from the coeliac plexus.

Free hydrochloric acid in the stomach destroys many pathogenic organisms and therefore serves as an *antiseptic barrier*. It also has the function of *liberating iron* from organic compounds and making it more assimilable. The stomach and duodenum secrete *haemopoietin*, which reacts with an extrinsic factor in meat and other foods to produce an active principle necessary for normal erythropoiesis. Despite its many functions good health may be enjoyed after complete removal of the stomach.

To Explore the Stomach.—An incision is made in or near the midline above the umbilicus. When the peritoneal cavity is opened, the first viscus to appear is either, and usually, the pyloric portion of the stomach, or the transverse colon with or without the greater omentum. Above, there may be seen the anterior edge of the liver The field may be obscured to some extent by the falciform ligament of the liver.

The pyloric portion of the stomach is drawn out of the wound, inspected, and palpated. It is then drawn to the right side to display the lesser curvature and the anterior surface of the body; then to the left to facilitate access to the duodenum. The right hand is now passed upwards, below the ribs and the left lobe of the liver, to palpate the fundus and the cardia.

The posterior wall of the stomach is approached through the lesser sac. A vertical incision is made in the anterior layer of the greater omentum to the left of the midline, and through this opening the posterior wall may be palpated and portions of it inspected. Very free access to the posterior wall of the stomach and to the first part of the duodenum may be obtained by severing the almost bloodless peritoneal attachment of the greater omentum to the transverse colon (Pauchet)

Gastrotomy.—It may be necessary to open the stomach in order to remove a foreign body, to secure a bleeding vessel, or to inspect the mucosa.

If the foreign body is radio-opaque it is wise to make certain that it is still in the stomach by screening the patient immediately before operation The abdomen is opened through a left paramedian incision above the umbilicus. The foreign body is sought with the fingers, and when found is pushed against the anterior wall of the stomach and protruded as far as possible through the wound in the parietes The segment of stomach containing the foreign body is packed off with gauze, and a small incision made over the most projecting part of the body at right angles to the long axis of the stomach. The foreign body is removed, and the wound is closed by a continuous through-and-through catgut suture, reinforced with a seromuscular suture.

For the removal of a large foreign body impacted in the lower end of the oesophagus or in the duodenum, or to expose and secure a bleeding vessel, the opening must be much larger. A sufficient portion of the anterior wall of the stomach is presented and retained by two traction sutures. After packing off with gauze, the stomach is opened in its long axis and any fluid is aspirated. The edges of the stomach wound are seized and held apart with several pairs of fine forceps. When the object of the operation has been attained the opening is closed in the usual tiers of sutures.

Longitudinal wounds in the region of the pylorus should be stitched at right angles to the long axis of the wound to avoid narrowing the lumen.

Gastrostomy.—This operation may be performed when the gullet is obstructed, in order that nourishment may be introduced directly into the stomach It is essential that the fistulous opening should be made valvular so that neither food materials nor gastric secretion can escape from it. Of the numerous methods recommended for making a valvular fistula, that of Senn is the most satisfactory. The operation is well borne under local anaesthesia.

An incision of moderate length is made vertically through the upper half of the left rectus. As the stomach is empty and contracted as a result of prolonged starvation it does not as a rule present in the wound and must be sought beneath the left lobe of the liver. The patient is asked to take a deep breath, and when the stomach comes into view it is secured by a toothed forceps or in the loop of a silk suture. The stomach is identified by its comparatively thick, smooth wall, and by the distribution of the blood-vessels proceeding from the greater curvature. If there is still doubt, the viscus may be traced with the fingers to the under surface of the diaphragm. A part of the anterior wall is selected as far from the pylorus as possible, withdrawn, and packed off in the usual way.

In forming the fistula an opening is made in the stomach just large enough to admit a rubber tube about the size of a No. 10 English catheter; the tube is about 2 feet long and should have both a terminal and a lateral opening It is pushed into the stomach for about 5 cm. (2 in) towards the pylorus, and secured to the edge of the opening by means of a catgut stitch passed through its wall and through all the coats of the stomach. About 1½ cm. (⅝ in.) away from the opening a purse-string suture is inserted, and while this is being tightened and tied the opening and tube are invaginated into the stomach. A second purse-string suture serves to invaginate them still farther, and even a third may be used (Fig. 152). The thread used for the last suture is carried through the edge of the parietal peritoneum and the sheath of the rectus, in order to fix the stomach

to the abdominal wall. The tube must be secured by stitches tied around it When the stitches are removed a convenient way of anchoring the tube is to pass a silver ring along the stretched tube until it lies flush with the skin. The ring is provided with eyes for

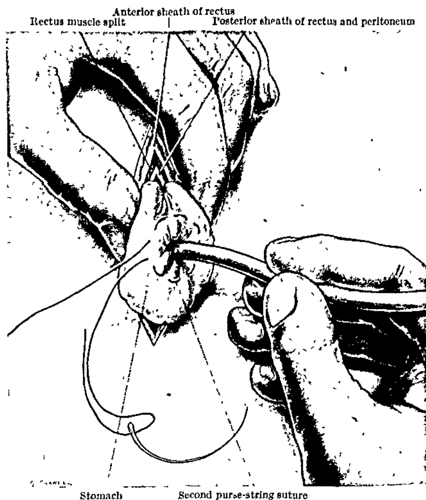


FIG 152. Gastrostomy by Senn's Method

tapes; these may be tied around the body or fixed by adhesive plaster

Ensure that the channel is clear and then plug the tube with a wooden spigot, and secure it to the dressing with a safety pin.

Congenital Hypertrophic Pyloric Stenosis.—Rammstedt's operation is the standard procedure (Fig. 153). It may be, and usually is, performed under local anaesthesia with little or no shock. Since the baby is often dehydrated, body fluid should be restored by subcutaneous injections of glucose-saline given by needle and syringe.

The stomach is washed out half an hour or so before operation and luminal gr. ½ is given in a little water through the stomach tube. It is convenient to have the child bandaged to a well-padded wooden cross (Fig. 153c).

The line of incision is infiltrated with ½ per cent. novocaine; and a vertical incision 4 cm. (1½ in.) long about 1·5 cm. (½ in.) to the right

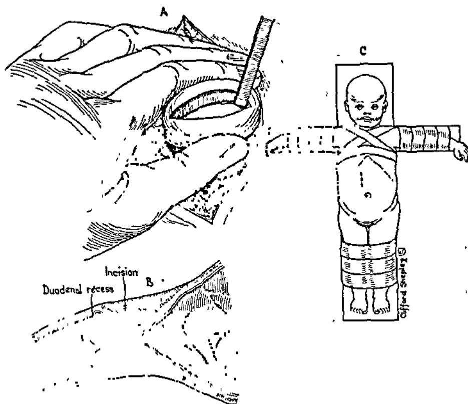


FIG. 153 Rammstedt's Operation for Congenital Pyloric Stenosis.

A = Division of Hypertrophic Muscular coats
B = Stippled area indicates extent of incision
C = Means of immobilizing patient

of the midline is made from the right costal margin. The fibres of the rectus are separated. On incision of the posterior rectus sheath and peritoneum the liver presents; it is gently retracted upwards to display the thickened pylorus. The stomach just proximal to the pyloric canal is caught with tissue forceps. The pyloric canal is then gently brought out and grasped with the left index finger and thumb, which exert pressure on the abdominal wall so as to relieve any strain on the peritoneal attachments of the pyloric canal. A longitudinal incision is made in the peritoneum over the thickened pylorus, usually in the bloodless area on the antero-superior surface. To avoid

injury to the subjacent mucosa the muscular coat is severed by a blunt instrument. The wound is deepened until the submucosa is freely exposed throughout the hypertrophied segment. At the pylorus particular care must be taken not to injure mucosa in the duodenal recess. Any bleeding-point is under-run with a fine linen suture. The pyloric segment is then replaced and the abdominal wound is sutured in layers.

The chief post-operative danger is gastro-enteritis. For the first six hours only occasional one-drachm doses of sweetened sterile water are allowed by mouth, the body fluid being maintained by subcutaneous injections of glucose-saline. Sterile water containing 5 per cent. glucose is then given hourly by the mouth, the amount of each feed being quickly raised to one ounce. By the eighteenth hour diluted citrated milk is substituted. In the absence of vomiting normal feeding is resumed on the third day. In breast-fed babies, especially if there are no facilities for isolation in hospital, it is often wise to allow the mother to take the patient home on the second day, and to resume normal feeding.

Gastric Ulcer

Indications for Intervention and Choice of Operation.—*Perforation* calls for immediate operation. The mortality rate rises with each hour that elapses between perforation and operation, and very steeply after the twelfth hour.

Chronic gastric ulcer, unlike duodenal ulcer, is potentially malignant. Moreover, it is not always easy to determine whether an ulcer demonstrated by X-rays is simple or malignant. In the fundus, the region of the greater curvature, and pyloric canal ulcers are to be regarded with grave suspicion and should be assumed to be malignant and treated as such.

In the common site, the region of the lesser curvature, an apparently simple ulcer should first be treated by medical measures. If, however, there is not unmistakable radiological evidence of healing within two or three months the ulcer is better dealt with surgically.

Many operations have been devised for chronic gastric ulcer, all of which include ablation of the ulcer (Fig 154). One which has been widely employed for ulcer on the lesser curvature is a *wedge-shaped resection*, combined with posterior gastro-enterostomy. It is now considered more satisfactory to perform a wider resection, to include the ulcer area and all the stomach distal to it. The standard operation is that of Polya, in which the stomach is divided above the level of the ulcer, and the distal part, together with the first part of the duodenum, is removed. A loop of jejunum is brought up through the

transverse mesocolon and united to the open end of the stomach, with the distal limb attached to the greater curvature.

Some surgeons prefer to conserve more of the stomach by retaining

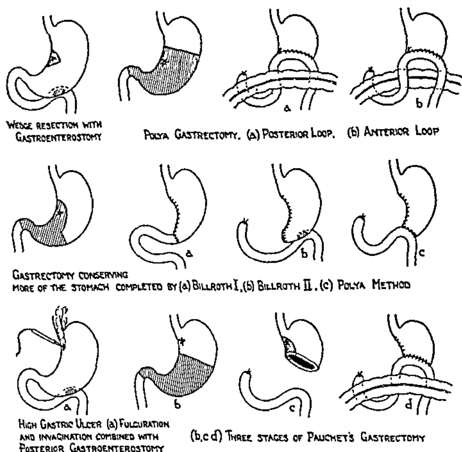


FIG. 154 Diagram to illustrate Operations for Gastric Ulcer.

(Billroth I) or the free end may be closed and a posterior gastro-enterostomy performed (Billroth II) or, what is probably most satisfactory, the operation is completed as a Polya resection. It is claimed that by conserving more of the stomach there is less interference with its function and less risk of anaemia.

Ulcer high on the lesser curvature presents special difficulties. If the ulcer is small and persists after medical measures it may be destroyed by the electric cautery or by fulguration, and the area invaginated by seromuscular sutures, the operation being completed by a posterior gastro-enterostomy. To reduce the risks of recurrence

injury to the subjacent mucosa the muscular coat is severed by a blunt instrument. The wound is deepened until the submucosa is freely exposed throughout the hypertrophied segment. At the pylorus particular care must be taken not to injure mucosa in the duodenal recess. Any bleeding-point is under-run with a fine linen suture. The pyloric segment is then replaced and the abdominal wound is sutured in layers.

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the pubis and the patient is placed in Fowler's position. The drainage tube may be shortened to the parietes in twenty-four hours.

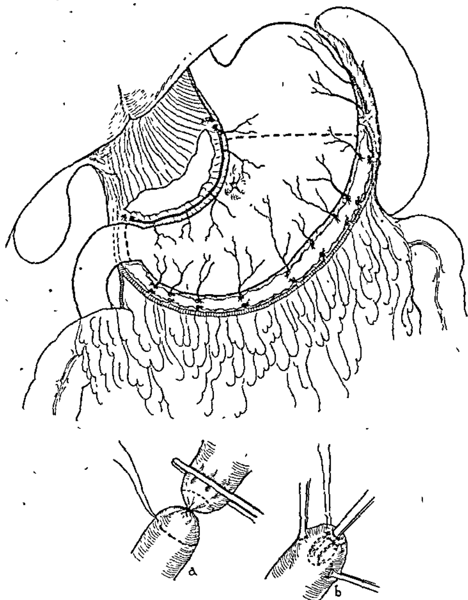


Fig 155. Gastrectomy for Gastric Ulcer.

a Duodenum closed with purse-string ligature
b Stump invaginated through a purse-string suture

Post-operative complications are not infrequent. Bronchitis with broncho-pneumonia, and massive collapse of the lung are the most common. A sharp lookout must be kept for the signs of subphrenic abscess and pleural empyema, particularly if intermittent pyrexia,

after this operation the patient should follow a definite medical régime.

A more radical procedure for gastric ulcer high on the lesser curvature is that of *Pauchet*. The stomach distal to the ulcer is resected. Through the open end of the stomach the lesser curvature is cut away to above the level of the ulcer. After resecting the lesser curvature the free edges are united by through-and-through sutures and reinforced by a series of Lembert sutures. The end of the stomach is then united to a loop of jejunum as in the Polya operation.

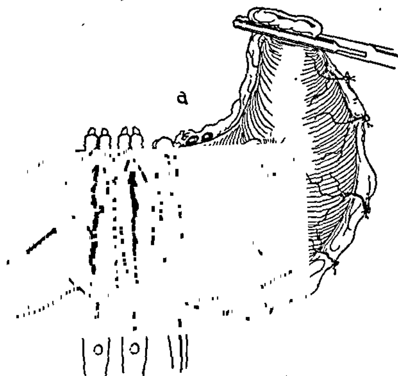
In frail and debilitated patients with chronic gastric ulcer the risks of operation may be prohibitive. If such patients do not respond to medical measures a jejunostomy may be performed under local anaesthesia. This allows the patient a highly nourishing fluid diet and gives complete rest to the stomach; usually his general condition may improve sufficiently to permit of gastric resection.

Operation for Perforated Gastric Ulcer.—If the rigid abdomen does not readily relax under inhalation anaesthesia it is advantageous to give an injection of d-tubocurarine. Intercostal nerve-block produces good relaxation and, supplemented by light nitrous oxide and oxygen anaesthesia, is particularly suitable for this operation. The abdomen is opened through a right paramesial incision above the umbilicus, the rectus being either split or retracted. Free fluid is removed by suction. The stomach is grasped with a moist swab and pulled downwards and to the right. The perforation is usually on the anterior surface near the lesser curvature The maximum deposit of fibrinous lymph, or the bubbling out of gas, indicates the site of perforation If the perforation is not found on the anterior surface of the stomach (or duodenum) the lesser sac must be entered below the greater curvature and the posterior surface of the stomach and duodenum inspected

The perforation is closed by three or four linen mattress sutures placed, to prevent narrowing, in the long axis of the viscus. If individual sutures are tied they are apt to cut out, and it is better to introduce all the sutures and tie each while the others are held taut. An omental graft may be applied to reinforce the suture line (Fig 158*b*).

With a sucker, fluid is removed from the hepato-renal recesses and from the pelvis. If mops are used care must be taken not to injure the peritoneum by friction.

When there has been but little escape of contents and the peritoneal exudate is scanty, drainage is not required If the exudate is copious and contains obvious food particles, or is already purulent, a rubber drain is inserted into the pelvis through a stab wound above



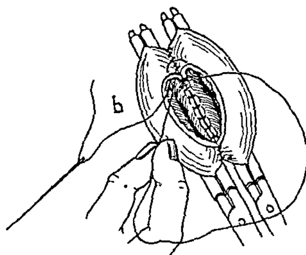


FIG 156 Gastrectomy. Anastomosis of Jejunal Loop.

a Posterior Lembert sutures inserted (Posterior through-and-through suture to be inserted before detaching portion of Stomach to be removed.)
b Insertion of Anterior through-and-through invaginating suture.

with accelerated respiration, persists for many days. When doubt exists an exploring needle should be introduced without delay.

The Polya Resection for Chronic Gastric Ulcer.—High nupercaine spinal anaesthesia, combined with nitrous oxide and oxygen inhalation anaesthesia, gives good relaxation and facilitates the operation. Some surgeons prefer infiltration anaesthesia for the parietes and anterior splanchnic anaesthesia for the viscera.

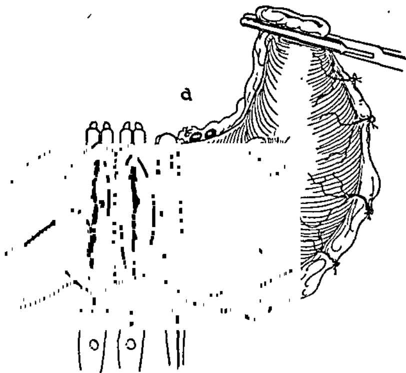
The abdomen is opened by a left paramesial incision, the rectus being retracted laterally. The stomach, first part of duodenum, gall-bladder, and appendix are each examined. The site of the gastric ulcer is noted, and also any fixation to adjacent viscera such as liver or pancreas. The greater curvature is freed by dividing between ligatures the branches passing from the gastro-epiploic vessels to the stomach, care being taken to see that the transverse mesocolon is not adherent behind and that the middle colic vessels are not endangered (Fig. 155).

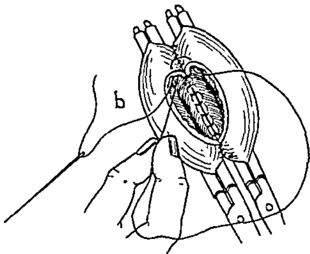
The small vessels passing from the right gastro-epiploic artery to the lower border of the pylorus are carefully tied with fine linen threads. A dissector is passed under the right gastric artery at the upper border of the first part of the duodenum, and the vessel is divided between linen ligatures. The first part of the duodenum is gently freed from the head of the pancreas. One or two small branches of the gastro-duodenal artery entering the posterior aspect of the duodenum usually require ligation. A linen purse-string suture is then inserted immediately beyond the pylorus and tied. A second linen purse-string suture is inserted in the duodenum 2 cm. (¾ in.) distal to the tied suture A crushing clamp is applied to the pylorus, and the duodenum is divided proximal to the tied suture with a knife *dipped in carbolic acid, or by the cautery. The duodenum* immediately beyond the untied purse-string suture is steadied by tissue forceps. The stump is then invaginated and the purse-string suture tied

The stomach is now turned to the left. If the ulcer has penetrated the pancreas the stomach is gently stripped or dissected free, the sucker being available to prevent soiling by escaped gastric contents; after mopping away any exudate on its surface the ulcer base on the pancreas can be safely disregarded.

When the stomach is turned well to the left, the left gastric artery is on the stretch and can be readily isolated near the point where it reaches the lesser curvature The vessel is divided between ligatures. The distal portion is stripped down the lesser curvature for about 5 cm. (2 in.); the tributaries passing to the stomach are ligated before being severed.

A crushing clamp is applied across the stomach above the level of


a


b

the ulcer. The first loop of jejunum is brought through an aperture in the transverse mesocolon to the left of the middle colic vessels. Should the transverse mesocolon be narrow, or the vessels not conveniently placed, the jejunal loop may be brought up in front of the transverse colon. The jejunum is applied to the stomach so that it runs *from the lesser to the greater curvature; care must be taken* that the loop is not twisted. After inserting a continuous linen Lembert suture, occlusion clamps are applied to the stomach proxi-



FIG 157 Completed Polya Gastrectomy. Aperture in transverse mesocolon sutured to stomach to prevent herniation of jejunum into lesser sac.

mal to the suture and to the jejunum parallel with the suture. The parts around are covered with moist towels. The stomach and jejunum are now incised on either side of the suture and a posterior through-and-through haemostatic suture of catgut is inserted (Fig. 156). The stomach is severed close to the crushing clamp. The anastomosis is then completed by a through-and-through invaginating catgut suture to unite the anterior layers of the stomach and jejunum, and by a reinforcing Lembert suture of linen. To make these parts secure it is wise to insert a few interrupted linen seromuscular sutures at the upper and lower extremities of the anastomosis. Care must be taken that the jejunum is not narrowed at the lesser and greater curvatures. The aperture in the transverse mesocolon is drawn up and sutured to the stomach a short distance from the anastomosis (Fig. 157)

For twenty-*four hours after the operation only sips of* water *are* allowed by mouth. Fluid is supplied subcutaneously or by rectum.

Thereafter fluid nourishment is given in increasing quantities, and on the seventh day steamed fish, soft bread and butter, minced chicken, and other easily digested foods are added to the diet. At the end of two weeks the patient is usually out of bed and taking an ordinary light diet.

Duodenal Ulcer

Indications for Operation.—*Perforation* of a duodenal ulcer calls for urgent surgical intervention.

Cicatricial stenosis of the duodenum following chronic duodenal ulcer interferes with the normal emptying of the stomach and clearly indicates surgical measures. A free exit from the stomach may be provided by a wide 'pyloroplasty' (Finney), by gastro-duodenostomy, or by gastro-enterostomy. The first two have been said to be more physiological, because the duodenum is more inured to acid than the jejunum. However, posterior gastro-enterostomy is the operation most frequently adopted in this country: it is relatively easy to perform, and, with due precautions gives satisfactory results. In duodenal stenosis, particularly in patients past middle life, the tendency to hyperacidity is diminished; nevertheless for a considerable period after operation patients should follow a medical régime to reduce the risks of anastomotic ulcer.

Active duodenal ulcer with hyperchlorhydria presents a more difficult problem. Formerly, gastro-enterostomy and gastro-duodenostomy were freely employed for this condition. The incidence of ulcer in the region of the anastomosis has been so large, and the complication when it arises so troublesome, that neither operation should be adopted for active duodenal ulcer with hyperchlorhydria.

Attempts have been made to reduce the gastric secretion by division of the vagus nerves, but the results so far obtained are not sufficiently encouraging to justify this as a routine procedure. Recently T. H. Somervell has advocated posterior gastro-enterostomy combined with ligation of the vessels passing to the lesser curvature, and five out of every six of the vessels passing from the vascular arcade along the greater curvature of the stomach—an operation which he terms *physiological gastrectomy* He believes that by so diminishing the blood-supply to the body and fundus of the stomach the function of the oxyntic cells is impaired, and adduces clinical evidence that for at least several years there is no tendency to hyperchlorhydria, and consequently no risk of anastomotic ulcer. If these findings are confirmed this operation may be widely adopted, since the immediate operative risk is relatively slight.

In the meantime the standard operation is *subtotal gastrectomy*, which aims at removing a large part of the acid-secreting portion of

the stomach. The results of this operation are satisfactory, but the operation is one of considerable magnitude and should be adopted only when a patient with active duodenal ulcer has had recurrent haemorrhages or continues to suffer disability despite prolonged medical measures

Operation for Perforated Duodenal Ulcer.—The perforation is closed by inserting three or four Lembert sutures of linen, the line of invagination being at right angles to the long axis of the duodenum. It is well to insert all the sutures and to tie each while the others are held taut. For the rare perforation on the posterior aspect of the duodenum access is obtained by opening the lesser sac below the greater curvature.

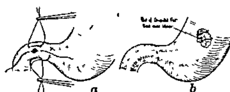


FIG 158 Perforated Peptic Ulcer.

a Closure of perforated Duodenal Ulcer
b Gastric Ulcer covered with pad of omental fat after closure.

The indications for drainage of the peritoneal cavity and the post-operative risks are the same as in perforated gastric ulcer (p 374).

If the duodenal ulcer is of long standing and has given rise to stenosis it may be necessary to perform gastro-enterostomy; but this step must not be added without due consideration.

Posterior Gastro-enterostomy.—If there has been much gastric retention and vomiting the patient should have several days' preparation. The stomach is washed out daily to allow it to regain tone and to reduce oedema Dehydration should be corrected by giving fluid by the rectum, subcutaneously, or intravenously.

The anastomosis is made between the first part of the jejunum ('no-loop' anastomosis) and the lowest part of the stomach, usually near the junction of the body and pyloric antrum. Occlusion clamps are useful to control bleeding and to prevent the escape of contents.

ulcer.

The abdomen is opened above the umbilicus in or near the midline. After a systematic examination of the duodenum, stomach, gall-bladder, and appendix, the omentum and transverse colon are withdrawn and turned upwards The middle colic artery and its main branches are recognized A bloodless area to the left of the

middle colic artery is selected and through it is made an opening into the lesser sac (Fig. 159).

The highest coil of jejunum is then found by passing the fingers of the right hand backwards beneath the mesocolon, immediately to the left of the spinal column and just below the pancreas. The relation of the first part of the jejunum to the stomach must be carefully studied in order to determine the most suitable direction in which to anastomose the jejunum to the stomach. The opening in the jejunum

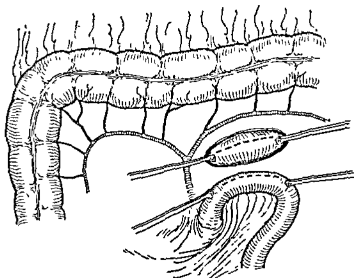


FIG. 159. Infracolic Approach for Posterior Gastro-enterostomy.

is made in its long axis and that in the stomach is usually made in the same direction close to the greater curvature. Whether the loop of jejunum should run from right to left, from left to right, or obliquely, depends upon how it is observed to lie best. In gastroptotic subjects the jejunal loop should be a little longer so that in the erect attitude there will be no drag on the duodeno-jejunal flexure.

The selected portion of stomach may be brought through the opening in the transverse mesocolon and the anastomosis performed with the colon and omentum still out of the abdomen. Especially if clamps are used, many surgeons find it more convenient to make an opening in the anterior layer of the omentum to the left of the mid-line, and with two fingers to bring up the highest part of the jejunum through the opening in the transverse mesocolon and through the lesser sac. The colon and omentum can then be replaced in the abdomen.

To the selected portions of the stomach and jejunum clamps are applied and approximated. Moist towels are placed around the parts

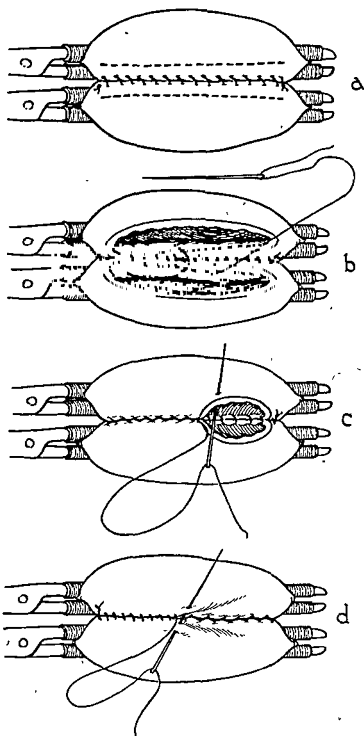


FIG. 160. Gastro-enterostomy Stages of Stitching.

to be anastomosed. A posterior continuous fine catgut Lembert suture is inserted (Fig. 160*a*). Parallel incisions open the jejunum and stomach about 0·5 cm. (½ in.) from the Lembert suture. The opening should be about 5 cm. (2 in) long, or a little more if the stomach is dilated. A continuous catgut suture is then inserted through all the layers to unite the free posterior edges, and it is continued as an invaginating suture round the anterior free edges. To ensure occlusion of vessels the suture should be held taut, and it is an advantage to use an occasional 'back stitch'. The anterior through-and-through suture is reinforced by a continuous Lembert suture. If the approach has been through the lesser sac the opening in the anterior layer of the greater omentum is closed. Finally, the edges of the opening in the transverse mesocolon are stitched to the stomach a short distance from the line of anastomosis.

Anterior Gastro-enterostomy.—If narrowness of the transverse mesocolon or the presence of vascular anomalies renders posterior gastro-enterostomy impracticable, duodenal stenosis may be relieved by *anterior gastro-enterostomy*. The highest loop of jejunum is brought up in front of the transverse colon and anastomosed to the lowest part of the anterior surface of the stomach, just to the left of the pyloric antrum. In anterior gastro-enterostomy the necessary loop of jejunum is longer than that in posterior gastro-enterostomy and there is greater risk of 'vicious-circle' vomiting. Therefore, if posterior gastro-enterostomy is not possible, it is usually wiser to resort to partial gastrectomy.

The immediate post-operative treatment is similar to that after partial gastrectomy (p. 378), and the recovery is usually smooth. If there should be vomiting the patient may be relieved by an in-dwelling gastric tube, and glucose-saline should be given parenterally. If the regurgitation of gastric and duodenal contents persists a 'vicious circle' due to technical errors must be suspected, and it may then be necessary to make an anastomosis between the limbs of the jejunal loop

When the patient leaves hospital he is given instructions as to diet, and is advised to take antacid powder for at least three months.

Partial Gastrectomy.—For active duodenal ulcer with high gastric acidity the operation of choice is resection of three-quarters to four-fifths of the stomach; the Polya method is usually employed (Fig. 161).

The duodenum is inspected and palpated to determine the site of the ulcer or ulcers, and any fixation to the head of the pancreas; the stomach, gall-bladder, and appendix are also examined.

The greater curvature is freed by dividing the branches passing from the gastro-epiploic arteries to the stomach, and at a higher level

some of the vasa brevia. If there is no gastric ulcer the left gastric artery can easily be identified on the lesser curvature; it is divided between ligatures a little above the proposed line of section of the stomach.

If the first part of the duodenum is not unduly fixed posteriorly it is freed as described in the Polya resection for gastric ulcer. The

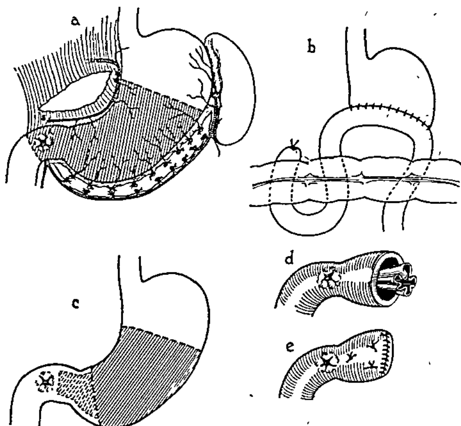


FIG. 161 Gastrectomy for Duodenal Ulcer.

a. Extent of resection.
b. Gastrectomy completed by Polya Method
c, d, e. To illustrate procedure when duodenum is unusually fixed.

occluding purse-string suture of linen is inserted at the level of or just beyond the ulcer. The invaginating suture is inserted 2 cm. (¾ in.) distal to the first suture

Not infrequently a posterior duodenal ulcer penetrates the head of the pancreas, and the duodenum may be firmly fixed to adjacent vessels and to the common duct To dissect the duodenum sufficiently free to provide a segment for invagination is a difficult and sometimes a dangerous procedure. It is safer and probably equally effective to divide the stomach about 4 cm. (1½ in.) to the left of the

pylorus. Clamps are first applied to the stomach to prevent escape of contents, and the surrounding parts are covered with moist towels. The mucous membrane of the pyloric canal is dissected free and removed, its remaining edge near the pylorus being carefully sutured. The pyloric canal is obliterated by a few antero-posterior mattress sutures and the free end closed by a continuous catgut suture (Fig. 161*c*, *d*, *e*).

The stomach is now turned to the left, clamps are applied near the level at which it is to be divided, and the operation is completed as in the Polya resection for gastric ulcer (p. 376).

Anastomotic Ulcer

Though occasionally an anastomotic ulcer occurs after partial gastrectomy for peptic ulcer, especially if there has not been a wide resection of the acid-secreting portion of the stomach, the chief incidence of anastomotic ulcer is after gastro-enterostomy for duodenal ulcer with hyperchlorhydria. Now that it is realized that simple gastro-enterostomy is indicated for duodenal ulcer only when there is stenosis with low gastric acidity, anastomotic ulcer should eventually become less frequent. In the meantime the surgeon must be prepared to deal with this troublesome complication.

The only effective treatment is to undo the anastomosis and to resect a portion of the stomach wide enough to ensure a low acid secretion Access is obtained through a left paramedian incision. The omentum and transverse colon are raised and the region of the anastomosis is inspected. The transverse mesocolon is detached from the stomach close to the anastomosis, care being taken not to injure any of the vascular loops of the middle colic artery. Enough of the stomach is brought down through the opening and secured by tissue forceps to prevent its slipping back into the lesser sac. A small opening is made in the line of the anastomosis and the contents of the stomach are aspirated The jejunum is then separated from the stomach with scissors. The openings in the stomach and jejunum are each closed by through-and-through sutures and a superimposed Lembert suture—the lines of closure in each being transverse to the long axis. The operation is then completed by a Polya resection of the stomach.

The anastomotic ulcer associated with a gastro-enterostomy may penetrate the transverse colon and give rise to a *gastro-jejunocolic fistula*. The patient may then become markedly debilitated and toxic, the stomach and jejunum being inflamed and oedematous and their contents highly infective. To separate the viscera, to close the opening in each, and to resect the greater part of the stomach is a formidable procedure and invites great risk.

If the patient is reasonably fit and radiographs show the duodenum to be patent, the risk of operation may be diminished by carrying it out in two stages. The colon, stomach, and jejunum are separated and each closed. Later, when the patient has sufficiently recovered to allow of the second stage, a subtotal resection is performed by the Polya method.

If the duodenum is not patent, or if the condition of the patient is such that the undoing of the gastro-enterostomy and gastrocolic

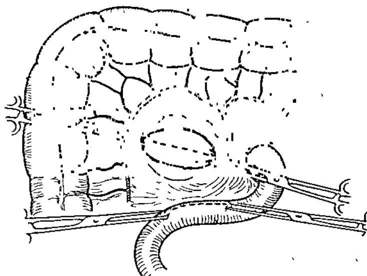


Fig 162. Duodeno-jejunostomy for Duodenal Ileus.

fistula is fraught with too much danger, it is wise to bring out a loop of the right half of the transverse colon and to make a temporary colostomy in order to deflect the colonic contents from the region of the fistula The patient's condition usually quickly improves, and in a few weeks he may be sufficiently fit to withstand the operation of undoing the gastrocolic fistula and the anastomosis, and partial gastrectomy. The final stage is closure of the colostomy.

Duodenal Ileus

Chronic duodenal ileus, in which there is evidence that the obstruction is situated at the point of crossing of the superior mesenteric artery, may be relieved by duodeno-jejunostomy. The abdomen is opened to the right of the midline, the rectus being displaced laterally. The transverse colon with the omentum is turned upwards. The peritoneum in the line of the duodenum is incised below the root of the transverse mesocolon and to the right of the superior mesenteric artery. Care must be taken to avoid branches of

the right and middle colic arteries. The duodenum is gently freed so as to allow of the application of curved occlusion clamps. A loop of jejunum is chosen conveniently near the duodeno-jejunal flexure and clamps are applied to it. The anastomosis, which should be about 5 cm. (2 in.) in length, is performed in the same manner as a gastro-enterostomy, the sutures being of fine catgut. The edges of the peritoneum are then stitched to the duodenum close to the line of anastomosis.

Gastric Carcinoma

When gastric carcinoma is evident or suspected, operation should be urged unless there are definite contra-indications, such as spread to the lymph nodes at the root of the neck, deposits in the pelvis revealed by vaginal or rectal examination, nodular enlargement of the liver, ascites, and lymphatic permeation to the umbilicus.

Several days of preparation are advisable, particularly if there is pyloric obstruction. Daily lavage will reduce the bacterial content of the stomach. Dehydration is corrected by glucose-saline given subcutaneously or intravenously. If there is anaemia whole blood-transfusions should be given several days before operation in order to raise the haemoglobin and cell levels and to allow of restoration of impaired liver function.

High nupercaine spinal anaesthesia provides good relaxation and reduces to a minimum the necessity for retraction. If low blood-pressure precludes spinal anaesthesia satisfactory relaxation can be obtained by intercostal nerve block, local infiltration of the abdominal wall and anterior splanchnic anaesthesia, combined with the inhalation of nitrous oxide and oxygen, or cyclopropane and oxygen.

The abdomen is opened through a left paramedian incision extending from the inner end of the seventh left costal cartilage to a little below the umbilicus, and the rectus is retracted laterally. A speedy but thorough investigation is carried out to determine operability. Dissemination in the general peritoneal cavity or in the lesser sac, metastases in the liver, and extension to the parietes, rule out any attempt at cure. Fixation of the tumour to the transverse colon is not in itself a contra-indication, though this means resection of a portion of the transverse colon.

If the tumour is situated in the region of the cardia or fundus total gastrectomy is indicated. When the tumour involves the oesophageal opening the lower part of the gullet and the region of the cardia, together with the nodes associated with the left gastric artery, must be removed, and to accomplish this the best approach is through the thorax.

Partial Gastrectomy.—In carcinoma of the distal part of the

If the patient is reasonably fit and radiographs show the duodenum to be patent, the risk of operation may be diminished by carrying it out in two stages. The colon, stomach, and jejunum are separated and each closed. Later, when the patient has sufficiently recovered to allow of the second stage, a subtotal resection is performed by the Polya method.

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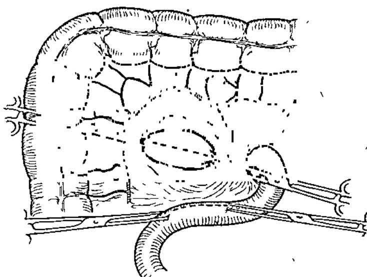


FIG 162 Duodeno-jejunostomy for Duodenal Ileus.

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at the upper border of the first part of the duodenum and ligated. The first inch of the duodenum is freed and divided as described in partial gastrectomy for peptic ulcer (p. 383) (Fig. 161).

The stomach is now turned to the left. This will make the left gastric artery taut, and it can readily be identified and divided

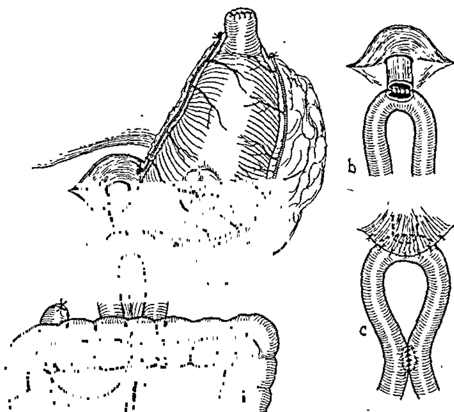


Fig. 164. Total Gastrectomy for Carcinoma.

'ower end of

between ligatures near its origin. The artery, together with the associated lymph nodes, is separated as far as the stomach, and is then stripped down the lesser curvature, the small vessels passing to the gullet and stomach being ligated before they are severed. The greater curvature is further freed by dividing the left gastro-epiploic artery near its origin from the splenic artery and a few of the lower vasa brevia. Crushing-clamps are now applied across the stomach, well above the lesion, and the operation is completed by the Polya method (p 376).

stomach the radical operation consists in resecting at least three-quarters of the stomach, the greater omentum, the vascular arcade along the greater curvature, together with its associated lymph nodes, the lymph nodes in relation to the pylorus, the left gastric artery from its origin, and the chain of lymphatics associated with the

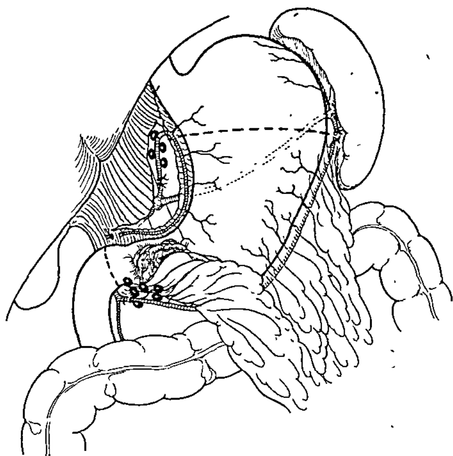


FIG 163. Gastrectomy for Carcinoma of Pylorus, showing extent of Stomach and Duodenum (between dotted lines), Great Omentum, and Vascular and Lymphatic Connexions to be removed.

vessels along the lesser curvature of the stomach, including the central lymph nodes in the region of the coeliac axis.

The omentum is detached from the colon; very few vessels require to be ligated. The lesser sac is thus freely opened and the extent of the tumour on the posterior surface of the stomach can be determined.

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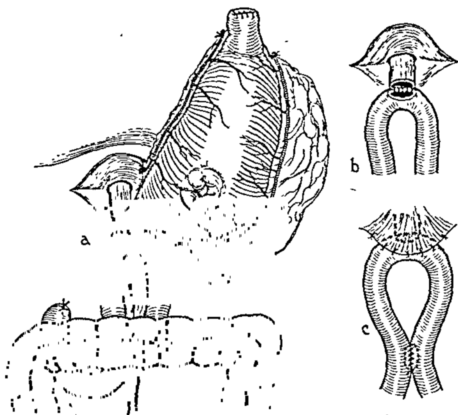


FIG. 164. Total Gastrectomy for Carcinoma.

lower end of

between ligatures near its origin. The artery, together with the associated lymph nodes, is separated as far as the stomach, and is then stripped down the lesser curvature, the small vessels passing to the gullet and stomach being ligated before they are severed. The greater curvature is further freed by dividing the left gastro-epiploic artery near its origin from the splenic artery and a few of the lower vasa brevia. Crushing-clamps are now applied across the stomach, well above the lesion, and the operation is completed by the Polya method (p. 376).

Total Gastrectomy.—The initial steps are the same as those in partial gastrectomy. The greater curvature must be freed to the oesophagus, and this necessitates dividing all the vasa brevia. Any enlarged glands must be carefully freed and left attached to the stomach The peritoneum extending from the diaphragm on to the gullet and stomach is incised and dissected up as a small flap. By gentle traction a further 2·5 cm. (1 in.) of gullet can easily be brought down through the diaphragm. A loop of jejunum is passed up through

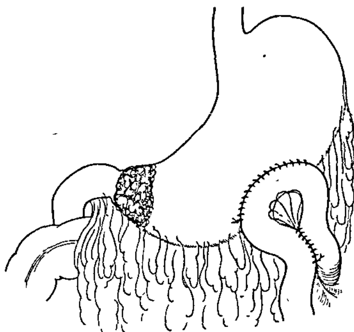


FIG. 165 Anterior Gastro-enterostomy: Limbs of Jejunal Loop Anastomosed to reduce risk of Vicious Circle.

an aperture made in the transverse mesocolon or, if it is preferred, brought up in front of the colon. The stomach is turned up and the jejunum attached to the posterior surface of the oesophagus by a Lembert suture of linen. A curved clamp is applied to the stomach near the oesophageal opening to prevent escape of contents. The operation area is surrounded with moist towels and a sucker is held ready for any fluid that may escape from the oesophagus. Incisions in the gullet and jejunum are made parallel with the Lembert suture. A posterior catgut suture is inserted through all the layers. The anterior wall of the gullet is severed and the stomach removed. The anastomosis is completed by a series of invaginating mattress sutures of catgut, reinforced by a Lembert suture of linen. Finally, the peritoneal flap is brought down over the line of anastomosis and

sutured to the jejunum to prevent drag. If the jejunal loop has been brought up through the transverse mesocolon the margins of the aperture are sutured to the two limbs to prevent herniation of small bowel.

For two or three days after the operation only occasional sips of sterile water are allowed by the mouth, the body fluid being maintained parenterally. Thereafter nourishing fluids are given in increasing quantities. Soft foods may be allowed after fourteen days. For some time the meals should be small and frequent. Eventually, however, a medium-sized meal will be tolerated without discomfort. After total gastrectomy the patient's blood should be examined from time to time, and if there be any evidence of hyperchromic anaemia liver extract should be administered.

Palliative Operation for Gastric Carcinoma.—Though not much can be expected in the way of prolongation of life, gastro-enterostomy does afford relief to patients with malignant disease which obstructs the distal part of the stomach. The choice of anterior or posterior gastro-enterostomy will depend on the relative extent of the disease on the two surfaces The opening in the stomach may be a little more to the left than in gastro-enterostomy for duodenal stenosis. Since there is no tendency to anastomotic ulcer, in anterior gastro-enterostomy the limbs of the jejunal loop may be anastomosed to each other to obviate any risk of 'vicious-circle' vomiting (Fig. 165).

In obstruction of the l[illegible] disease gastrostomy may p[illegible] as a rule is in complete a[illegible] practicable it is usually kinder to the patient to resort to sedatives. Should thirst occasion distress it may be relieved by rectal infusions of water.

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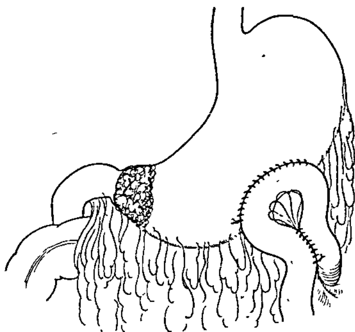


Fig. 165 Anterior Gastro-enterostomy: Limbs of Jejunal Loop Anastomosed to reduce risk of Vicious Circle.

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duodenum, and after running obliquely for 2 cm. (¾ in.) in the submucosa opens into the bowel by a common orifice, 8 cm. (3 in.) beyond the pylorus. Immediately proximal to the orifice the duct is dilated to form the ampulla, in which a gall-stone may lodge. In some subjects there exists an *accessory pancreatic duct* (duct of Santorini), and in about 10 per cent. the common bile-duct and the pancreatic duct open by separate orifices into the duodenum (Figs. 166, 173). Although the cystic duct normally admits a No. 5 catheter, on account of the way in which its mucous membrane is thrown into folds, the passage of a

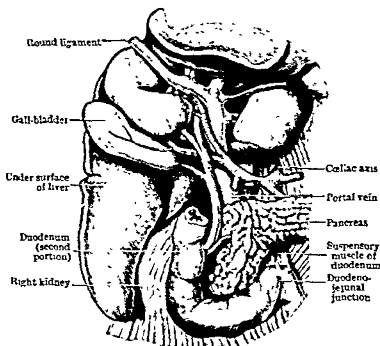


Fig. 166 The Connexions of the Biliary and Pancreatic Ducts (a portion of the head of the pancreas has been removed).
(After Zuckerkandl.)

probe along the duct is always difficult and may be impossible. The common duct is slightly larger than the cystic duct, but at its entrance into the duodenum it is so narrow that it admits only a fine probe. The gall-bladder is related to the hepatic flexure of the colon, and towards its neck to the first part of the duodenum, and occasionally to the pylorus. The *cystic artery*, the artery of supply of the gall-bladder, is a branch of the right hepatic artery and lies at a higher level and on a deeper plane than the cystic duct. Arterial abnormalities are frequent, however, and an accessory artery is not uncommon. The *accessory cystic arteries* and the normal vessel vary widely in origin and course.

Operations on the Liver and Bile-passages.—The abdominal route is that usually selected to obtain access to the liver and bile-passages, but sometimes a hepatic abscess or a hydatid cyst of the liver is better reached by the transpleural route.

The Abdominal Route.—Access to the deeper part of the gall-bladder and bile-ducts may be improved if a firm cushion or

CHAPTER XXIII

OPERATIONS ON THE LIVER, THE GALL-BLADDER, AND THE BILE-DUCTS

Anatomy. Wounds and Rupture of Liver. Cholecystostomy. Cholecystectomy. Choledochostomy. Choledochotomy. Cholecyst-gastrostomy. Cancer of Ampulla of the Bile-duct. Hepatic Abscess. Hydatid Cyst. Tumour. Cirrhosis of Liver.

Anatomy.—The left lobe of the *liver* extends across the epigastric region into the left hypochondrium, and is in contact with the anterior abdominal wall. It is therefore more accessible than the right lobe, which is overlapped by the ribs and roofed in by the diaphragm The space between the liver and the diaphragm is divided into right and left compartments by the falciform or suspensory ligament. The highest part of the liver, which corresponds also to the highest part of the right arch of the diaphragm, during expiration reaches the level of the fourth intercostal space in the mammary line In the erect posture, the lower edge of the right lobe projects slightly below the costal margin, in the recumbent position it is entirely under cover of the ribs; in the subcostal angle the left lobe intervenes between the stomach and the anterior abdominal wall. The under-surface of the right lobe is in relation from before backwards with the hepatic flexure of the colon, the duodenum at the junction of its first and second portions, and the right kidney and supra-renal capsule

The *gall-bladder* lies against the under-surface of the right lobe of the liver. Normally the fundus projects slightly beyond the free margin of the liver opposite the ninth or tenth costal cartilage. Under pathological conditions it may be displaced farther to the right, or it may be found high up beneath the liver and completely covered by it. From the fundus the bladder gradually narrows until its neck ends in a sigmoid curve, the terminal portion of which turns downwards to join the cystic duct near the right end of the transverse fissure of the liver. The fundus and inferior aspect of the bladder are invested by peritoneum; the superior aspect is connected to the under-surface of the liver by connective tissue, and under normal conditions is easily separated from it. The *cystic duct* passes backwards, downwards, and to the left for a distance of 4 cm. (1½ in), and joins the hepatic duct at an acute angle to form the common bile-duct The *hepatic duct* is formed by the junction of a branch from each lobe of the liver, issuing at the transverse fissure, and it descends within the gastro-hepatic omentum to join the cystic duct. The *common bile-duct*, formed by the junction of the common hepatic and cystic ducts, is about 8 cm (3 in.) in length, and passes downwards and backwards in the gastro-hepatic omentum, lying in front of the portal vein, and having the hepatic artery on its left side. Along its course are several lymph glands, which when

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a gall-stone may lodge. In some subjects there exists an *accessory pancreatic duct* (duct of Santorini), and in about 10 per cent. the common bile-duct and the pancreatic duct open by separate orifices into the duodenum (Figs. 166, 173). Although the cystic duct normally admits a No. 5 catheter, on account of the way in which its mucous membrane is thrown into folds, the passage of a

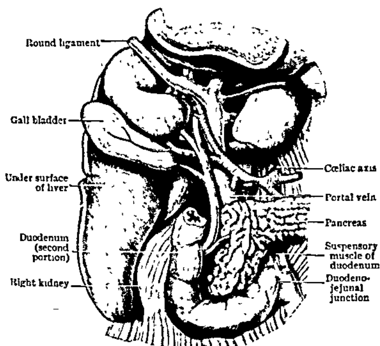


FIG. 166. The Connexions of the Biliary and Pancreatic Ducts (a portion of the head of the pancreas has been removed). (After Zuckerkandl.)

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Operations on the Liver and Bile-passages.—The abdominal route is that usually selected to obtain access to the liver and bile-passages, but sometimes a hepatic abscess or a hydatid cyst of the liver is better reached by the transpleural route.

The Abdominal Route.—Access to the deeper part of the gall-bladder and bile-ducts may be improved if a firm cushion or

sand-bag about 8 inches long, 6 inches wide, and 3 to 4 inches deep is placed behind the patient's back opposite the liver; the vertebral column is thus pushed forwards and with it the liver, so that the bile-ducts are brought nearer the surface, and in a thin person may be brought up almost to the level of the wound. The opening out of the costal angle also tends to favour a downward movement of the intestines away from the liver (Mayo Robson). This procedure is of real value only when an oblique or transverse abdominal incision is used.

Incisions.—Various incisions are available for the exposure of the bile-passages. In choosing the incision for an individual case the build of the patient will be the determining factor. In the thin asthenic type with a long and narrow costal angle a vertical incision through the medial third of the right rectus muscle will give adequate access with least disturbance of nerve supply. In the stout, squat subject, the common type for biliary disease, the oblique incision of Kocher, or a transverse incision, gives freer access, and, if properly used, rarely leads to hernia.

Kocher's incision (Fig. 141) starts at the midline and runs laterally for 12 or 15 cm (5 or 6 in), 2 5 cm. (1 in.) below and parallel to the costal margin. It divides the whole of the right rectus sheath and muscle The small eighth intercostal nerve may have to be sacrificed, but the larger ninth nerve is exposed and drawn laterally. In closing the wound it is not necessary to stitch the rectus muscle, which, at this level, does not retract, suture of the posterior and anterior layers of the rectus sheath brings the cut muscle margins into intimate contact (Fig 149)

Cholecystostomy.—Drainage of the gall-bladder, now largely superseded in the treatment of cholecystitis by cholecystectomy where that operation can be safely performed, is mainly reserved for the treatment of acute obstructive cholecystitis which fails to resolve, or threatens to proceed to perforation. Even in these circumstances cholecystostomy is preferred to removal of the gall-bladder only if the latter operation is hazardous by reason of the patient's age and frailty or of great technical difficulty.

It is often wiser to employ a local anaesthetic preceded by an injection of scopolamine-morphine The peritoneal cavity having been opened by an oblique or vertical incision, the fundus of the distended gall-bladder can, as a rule, be readily located. Omental adhesions are gently separated and the occluding stone is felt in the neck of the gall-bladder or in Hartmann's pouch. Moist gauze-packs are introduced around the gall-bladder, which is tapped with a large trocar and cannula The wall is then grasped by peritoneal forceps on either side of the puncture, the cannula is withdrawn, and the

opening enlarged. By means of gall-stone forceps or scoop any loose calculi are removed, and finally, by pressure with two fingers from without, the occluding stone at the neck is dislodged and removed.

It is essential that the obstructing calculus be extracted, otherwise a mucous fistula will result. Rarely, the stone at the neck is confined by an hour-glass constriction of the wall and must be directly cut down on and removed.

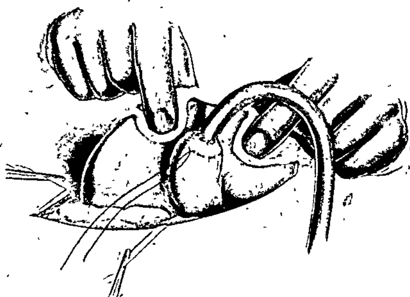


FIG. 167. Cholecystostomy; securing drainage tube in fundus of gall-bladder.

A stout rubber tube, one-quarter inch in outside diameter, is introduced into the gall-bladder and stitched to its wall. By means of a purse-string suture of fine catgut the gall-bladder wall around the opening is invaginated as in a Senn's gastrostomy (Fig. 167). The packs are removed and the wound is closed in layers around the tube, or the latter is brought out through a separate stab wound.

For ten days following the operation bile is allowed to drain into a bottle beside the bed. At the end of this time the surface stitch holding the tube is cut and the tube allowed to come away as soon as the deep catgut stitch has cut through or is absorbed. For a day or two a biliary fistula may remain, but if the ducts be clear the wound heals rapidly.

Cholecystectomy.—This is the operation of choice, whether calculi are present or not, if the gall-bladder presents such signs of disease as a loss of its serous sheen, an increase in subserous fat, an

inflammatory thickening of its wall, or inflammatory adhesions to neighbouring structures. If these signs of chronic cholecystitis are present, the cystic lymph gland is usually enlarged, and that portion of the liver which lies in relation to the gall-bladder is scarred.

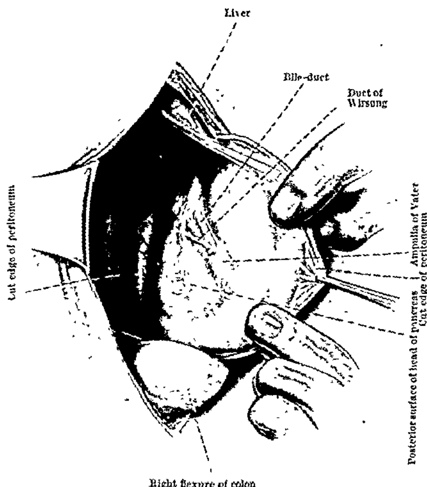


FIG 168 Exposure of Terminal Portion of Common Bile-duct and Duct of Wirsung by Mobilization of Duodenum.

A general anaesthetic is advisable, but in some cases a local or spinal anaesthetic may be employed An air-cushion, preferably with three compartments, is placed beneath the lower ribs, the shoulders being supported on pillows

The abdomen having been opened by one or other of the routes of access described on p 338, a general exploration is carried out. The state of the gall-bladder and liver is first noted, the common duct and head of the pancreas are palpated, and the state of the stomach and duodenum is ascertained A hand is then passed to the

iliac fossa, and if the caecum can be brought up into the wound, the appendix is removed.

Two gauze rolls pack off the stomach medially and the colon downwards, and a third fills the kidney pouch. One long, curved retractor draws the stomach to the left and another pulls down the duodenum and colon. The resultant of these two forces, acting through the lesser omentum, rotates the under-surface of the liver downwards, forwards, and to the left. Any peritoneal folds or

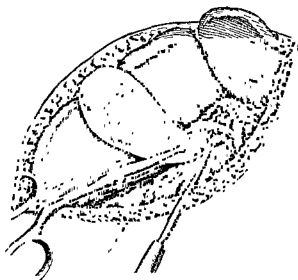


Fig 169 Cholecystectomy Ligature being passed round Cystic Duct.

adhesions joining the gall-bladder to the duodenum or colon are divided with scissors during this exposure.

Before the gall-bladder is dealt with, the common bile-duct is inspected If dilated or thick-walled it must be explored, even if no stone be palpable within it. The duct is first punctured with a hypodermic needle fitted to a 'record' syringe and some bile is withdrawn. If the bile is turbid the duct is infected and must be opened, emptied, and drained.

In removing the gall-bladder it is best to begin by dividing the cystic duct and artery and then to strip towards the fundus. It is important that the division of the duct and artery be carried out under full vision

hepatic artery. A

drawn forwards to straighten and tauten the cystic duct, which is dissected clear and ligated in continuity 1·25 cm (½ in.) from

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cystic vessels are then displayed and great care is taken that the right hepatic artery is not injured (Fig. 170); this vessel may accompany the cystic duct as far as the neck of the gall-bladder before diverging to enter the liver, and it may then be mistaken for its cystic branch. A ligature is passed round the cystic vessels and tied, a forceps is applied distal to the ligature, and the vessels are severed The peritoneal reflection from liver to gall-bladder is next

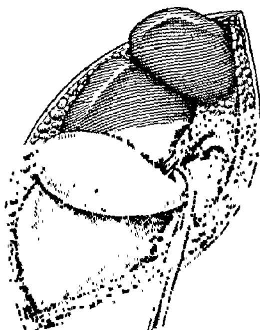


Fig 170 Cholecystectomy. Cystic Duct divided. Cystic *Artery exposed, pulling forward Right Hepatic Artery* ,

divided. This step is facilitated by injecting through a hypodermic needle a little saline below the peritoneum and cutting down on the oedematous area thus produced A few veins which run direct from the gall-bladder into the liver may have to be caught in forceps as the gall-bladder is stripped off, and occasionally a very small accessory bile-duct, emerging from the liver and entering the gall-bladder, may require ligation. If, just before its final separation, the gall-bladder, attached by the peritoneal attachment of its fundus, is drawn forward over the costal margin as a retractor, the gall-bladder bed can be covered by suture of its peritoneal margins. If dense inflammatory adhesions make difficult the separation of gall-bladder from liver, it is legitimate to cut away with scissors the serous-covered surfaces of the gall-bladder, this leaves, attached to the liver, the adherent area of gall-bladder wall, the mucosa of which may be destroyed by electro-coagulation The packs are removed,

a tube is inserted down to the stump of the cystic duct, the air-cushion is deflated, and the wound is closed in layers. The tube is left for three to five days and the patient is allowed up on the fourteenth day.

Choledochostomy.—This operation is called for in cases of stone in the hepatic or common bile-ducts, and in some cases of infective cholangitis without stone. The common duct may be opened above, behind, or through the duodenum. The two last-named routes are seldom required.

If the patient is suffering from obstructive jaundice, careful pre-operative treatment is required to minimize the risks of haemorrhage and of liver failure. The coagulation time of the blood is prolonged in jaundice by reason of a relative prothrombin deficiency due to failure of absorption of vitamin K from the intestine (in the absence of bile salts) and its imperfect utilization by the damaged liver. The prothrombin content of the blood may be elevated by the administration daily before operation of 2-methyl-4-naphthaquinone (menadione), which is pharmacologically equivalent to the vitamins of the K group. This yellow crystalline powder, insoluble in water, may be given by intramuscular injection in 0·5 per cent. solution in arachis oil, and in a dose of 10 mg. A similar compound, aceto-menaphthone, may be given by mouth. Blood transfusion by drip, begun before operation, should be continued during operation, and maintained after it. Liver insufficiency may be partly compensated by oral and intravenous administration of glucose before operation.

Supraduodenal Choledochostomy.—Access is obtained as in cholecystectomy (p. 395). The common duct is approached with as little disturbance of adhesions as possible. The left forefinger, passed behind the common duct and duodenum, may feel the obstructing stone. If the stone is movable it is manipulated into the supraduodenal portion of the duct, fixed there between finger and thumb, cut down upon, and removed by a gall-stone forceps. Before the duct is incised its anterior wall must be carefully cleared; exceptionally an abnormal or accessory cystic artery, or the right hepatic artery itself, may pass in front of it. After removal of the obstructing stone, the dilated duct is gently explored for other calculi with a gall-stone scoop, and the patency of its lower end is determined by the careful passage downwards to the duodenum, first of a soft bent probe, and then of a Lister bougie. If the duct contains biliary mud or inflammatory debris, this should be gently washed out with saline injected from a syringe along a rubber catheter, the returning fluid being collected by suction. The duct is then drained by a rubber tube, one-quarter inch in external diameter, inserted upwards towards the liver and anchored to the duct wall by a fine catgut

stitch. Further sutures close the duct around this tube. If the content of the duct has been frankly purulent two drainage tubes may be employed, one directed upwards and the other downwards; or a T-tube whose horizontal limb lies in the lumen. A second tube, inserted to lie beside the opening in the duct in case of leakage, is brought out, with the first, through the outer end of the wound or through a separate stab. The second tube is removed on the fourth

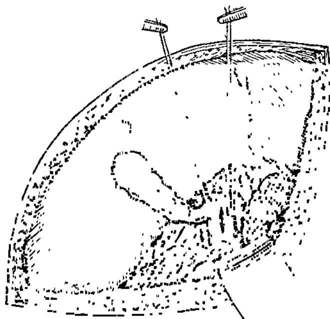


Fig. 171. Choledochostomy Stay Sutures fixing the Common Duct which has been incised

day, the first when its anchoring suture loosens, usually about the ninth day If the patient is ill and deeply jaundiced no attempt should be made to remove the gall-bladder for fear of haemorrhage from its liver bed; if it contains stones, these may be removed with the least possible trauma and disturbance of adhesions.

If the stone in the duct is tightly impacted and the patient deeply jaundiced, it is wise to be content with drainage of the dilated duct, postponing removal of the stone until jaundice has disappeared and liver function has improved.

If, on the other hand, jaundice is mild, or if the operation is performed, as is desirable, after recovery from jaundice, a more elaborate operation is permissible The common duct is opened between stay sutures, cleared of stones and debris by scoop and suction, proved patent by probe and bougie, and drained in the manner described above, the gall-bladder is then removed.

Retroduodenal Choledochotomy.—This operation is performed in the rare circumstance of a stone so firmly impacted at the lower end of the common duct that it can be neither manipulated upwards nor removed instrumentally from above nor reached safely through the duodenum. Access is obtained to the duct by incising the peritoneum around the superior angle and lateral border of the duodenum, which is mobilized forwards together with the head of the pancreas. An incision is then made through the duct wall directly on the stone, which is extracted. This wound in the duct is closed and the duct is drained through a supraduodenal opening.

Transduodenal Choledochotomy.—This route is applicable only to a stone immovably lodged in the actual ampulla. The termination of the bile-duct, including the stone, is grasped between the fingers and thumb of the left hand, and the anterior wall of the duodenum is cut through vertically in order to expose the posterior wall from within, with the termination of the duct running in it. The position of the duct is readily identified by feeling the stone impacted in its lumen. The duct is laid open by slitting up the papilla with a probe-pointed knife; bile escapes freely as soon as the obstruction is removed and must be mopped up as it flows. No sutures need be placed in the posterior wall of the duodenum. The incision in the anterior wall of the duodenum is closed in the ordinary way.

Repair of Common Bile-duct.—Traumatic stricture of the common bile-duct is usually the result of injury during the operation of cholecystectomy, and the operation of cholecyst-gastrostomy is therefore not possible for its relief. End-to-end anastomosis of the cut ends of the duct may be performed around a rubber T-tube whose vertical limb is brought out through a gap in the suture line, or around a flanged tantalum metal tube which remains permanently in place.

If extensive loss of duct prevents these procedures, a new bile-duct, fashioned from a semicircular flap of the anterior wall of the duodenum, may be anastomosed to the upper cut end.

Similar methods may be employed for the treatment of those rare cases of congenital obliteration of the bile-ducts in which the upper part of the common duct is patent and available for anastomosis.

Removal of Cancer of the Ampulla of the Bile-duct.—Cancer of the ampulla is relatively amenable to operation because it produces jaundice rapidly, comes to operation early, and metastasizes late.

The operation, which entails resection of the duodenum and of the head of the pancreas, is described on p. 410

Operation for Traumatic Lesions of the Liver.—*Penetrating wounds* of the liver are disclosed usually in the course of laparotomy performed for the exploration of a penetrating wound of the abdomen.

Subcutaneous rupture demands operation only if internal blood loss cannot be compensated by blood transfusion, or if concomitant injury to a hollow viscus is suspected. A tear in the liver gapes wider and bleeding from it increases, sometimes alarmingly, when the abdomen is opened and the intra-abdominal pressure falls.

If operation is performed, the abdominal cavity is opened by one or other of the incisions described on p. 338. If bleeding is still active, or if it recurs or increases, the left hand is passed immediately to the gastro-hepatic omentum to grasp between fingers and thumb the vessels which lie in its free edge. This temporarily stops all blood flow to the liver. The compressing fingers may then be replaced by a light intestinal clamp, which should be left applied for no longer than eight minutes at a time.

Bleeding having been thus temporarily controlled, the wounded liver may be inspected The upper surface may be quite widely exposed by dividing the round ligament between forceps and drawing downwards the upper forceps.

To arrest the haemorrhage permanently, if the bleeding vessels cannot be secured with forceps and ligated, the edges of the wound or tear should be brought together with a series of stout catgut sutures passed deeply through the liver substance with a round blunt needle, and a few fine catgut or silk sutures passed through the torn capsule. If the bleeding cannot be stopped in this way, the wound in the liver, if not large, may be plugged by omentum, but if it is large and there is loss of liver-tissue, it must be firmly packed with a long strip of gauze, the end of which is brought out at the parietal wound. Sometimes a combination of suturing and packing is necessary.

Operation for Hepatic Abscess.—The solitary or *tropical abscess* of the liver usually subsides completely after a thorough course of emetine administration, with or without aspiration of its contents; only rarely is operative evacuation required. The approach to a tropical abscess which has resisted treatment by emetine and aspiration, or to a pyogenic liver abscess due to any other cause, depends upon whether the abscess has extended to the upper or to the lower surface of the liver. In the latter case the abdominal route is employed, in the former the transpleural.

If the abscess is to be evacuated by the abdominal route, the liver is exposed by a suitable incision, care being taken not to disturb adhesions more than is necessary. If no adhesions are present the liver may be stitched to the parietal peritoneum to prevent pus entering and infecting the peritoneal cavity. The exposed area having been packed off with gauze, the exploring needle is introduced into the abscess and used as a guide along which to pass a

narrow-bladed knife or sinus forceps. A finger is passed into the abscess to break down septa and one or more drainage tubes are inserted.

Transpleural Operation.—When the abscess has spread upwards and is pointing towards the chest, the transpleural route is preferred.

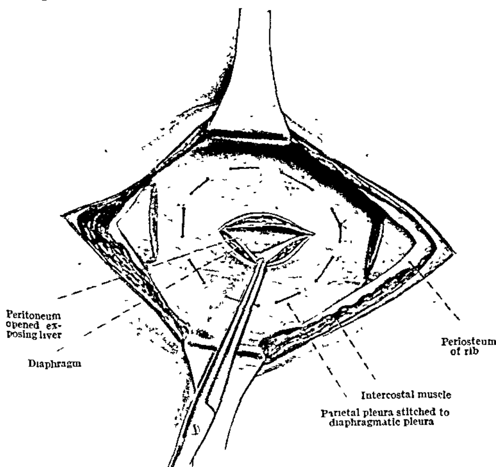


FIG. 172 Exposure of Liver by Transpleural Route.

The position of the lesion having been determined by X-ray or by needle exploration, an incision is made in the line of the seventh or eighth interspace, with its centre approximately in the mid-axillary line, dividing the skin and subcutaneous fascia, and the underlying fibres of the latissimus dorsi, external oblique, and serratus anterior muscles (Fig. 172) The edges of the wound are retracted to expose the two adjacent ribs, and a portion of each, about 8 cm. (3 in) long, is excised subperiosteally. The parietal pleura is separated from the chest wall around the wound as far as the finger can reach, to slacken it for suture to the diaphragm To prevent the entrance

of air, blood, or pus into the pleural cavity during the subsequent steps of the operation, the portion of the pleural space to be traversed is shut off from the rest by introducing, with a large, curved, round needle, a continuous circular suture to approximate the costal and diaphragmatic layers of the pleura. The stitches are passed through the intercostal muscles as well as through both layers of the pleura, and, at each end of the divided ribs, through the periosteum also The costal layer of the pleura is then incised sufficiently freely to expose the diaphragmatic layer, which is recognized by its bluish, glistening appearance This, together with the diaphragm, is incised, and if the underlying peritoneum is not adherent to the liver, a continuous circular suture is introduced to unite the parietal and visceral layers of the peritoneum. This suture is seldom required, as the inflamed liver is usually adherent to the diaphragm. The abscess cavity is then incised, emptied, and drained.

Hydatid Cyst is approached by abdominal or transpleural route according to its site. When the cyst is exposed the wound and the peritoneal cavity are protected by gauze packs, whose colour should be black or green to form a contrasting background for escaping cysts or portions of cyst wall. Once in place the gauze is moistened with 2 per cent. formalin solution. The cyst is then aspirated and as much fluid as possible removed, and a similar quantity of full-strength commercial formalin is injected by way of the same aspirating needle A pause of ten minutes is now made, with the needle *in situ*, after which the parasite is presumed to be dead. The content is again aspirated and the cyst wall is incised. The lining membrane of the cyst is completely removed by forceps, loose fragments of adventitia are cut away, and the resultant cavity is mopped again with 2 per cent. formalin, washed with saline, and obliterated by sutures or drained

Resection of the Liver for Tumour.—Resection of the liver for tumour should be undertaken only when the growth is primary and solitary, when its margins are clearly defined, when there is reasonable certainty that the whole of the tumour can be removed, and, in malignant cases, when a sufficient margin of healthy tissue can be cut away to make recurrence improbable. The operation is performed usually for the removal of a wedge of tumour invading the adjacent liver directly from a malignant gall-bladder.

The affected portion of the liver is freely exposed and the surrounding parts are packed off with gauze To secure a bloodless

sutures and the base of the tumour. The cut edges of the liver are then brought together by deep sutures of thick catgut, and a roll of dental rubber is fixed to the site of resection and brought out at the wound. The diathermy knife may be employed with advantage to divide the liver substance.

The simplest of all methods is the excision of a wedge-shaped portion of the liver, the ligation of the bleeding-points exposed on the cut surfaces, and the approximation of these by deeply placed interrupted sutures. During the operation the assistant controls haemorrhage by grasping the organ on each side of the line of incision or by compressing the vessels in the gastro-hepatic omentum.

Operative Treatment of Portal Hypertension.—The aim of operation in this condition has been to relieve portal congestion by establishing artificial anastomoses between portal and caval circulations, but gross liver insufficiency makes the operative risk high, and statistically it has not been shown that any available operation lengthens life appreciably even in those patients who survive intervention The Talma–Morison procedure, the stimulation of adhesions between liver and omentum on the one hand, parietal peritoneum on the other, is not now recommended. Recently a trial has been made of end-to-end anastomosis of splenic to renal vein after removal of spleen and left kidney, the expectation of life in those patients who survive the operation appears to be greater than that of patients not submitted to it, but the operative risk is considerable

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of air, blood, or pus into the pleural cavity during the subsequent steps of the operation, the portion of the pleural space to be traversed is shut off from the rest by introducing, with a large, curved, round needle, a continuous circular suture to approximate the costal and diaphragmatic layers of the pleura. The stitches are passed through the intercostal muscles as well as through both layers of the pleura, and, at each end of the divided ribs, through the periosteum also. The costal layer of the pleura is then incised sufficiently freely to expose the diaphragmatic layer, which is recognized by its bluish, glistening appearance. This, together with the diaphragm, is incised, and if the underlying peritoneum is not adherent to the liver, a continuous circular suture is introduced to unite the parietal and visceral layers of the peritoneum. This suture is seldom required, as the inflamed liver is usually adherent to the diaphragm. The abscess cavity is then incised, emptied, and drained.

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The affected portion of the liver is freely exposed and the surrounding parts are packed off with gauze To secure a bloodless

been tightly drawn the liver substance is divided between the line of

may be gained by incising the posterior leaf of the transverse mesocolon or by opening into the lesser sac through the gastro-colic omentum.

The customary treatment is to swab out all peritoneal exudate and to insert a drain of dental rubber down to the vicinity of the pancreas. Since gall-stones are often present and since the pancreatic necrosis is sometimes attributable to reflux of bile into the pancreatic duct, there is a rational basis for performing cholecystostomy (p. 394) in order to remove the stones and decompress the biliary tract. The patient's condition is usually not such as to permit of exposure and drainage of the common bile-duct.

Pancreatic Cyst.—A cyst of the pancreas may present above the lesser curvature of the stomach, between the stomach and the transverse colon, or below the transverse colon. According to its position access may be gained by dividing the lesser omentum, the gastrocolic omentum, or the transverse mesocolon.

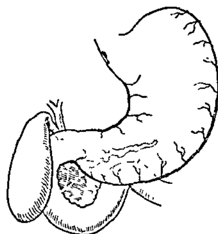


Fig 174 Carcinoma of Pancreas showing extent and situation of Tumour

When exposed, the cyst is opened and evacuated. A large drainage tube is then inserted. As a rule it is advisable also to establish counter-drainage through a stab incision in the loin. As an alternative it has been recommended to establish internal drainage by anastomosing the cyst to the stomach

Carcinoma of the Pancreas.—Carcinoma of the body or tail of the pancreas usually develops so insidiously that by the time the diagnosis is made the disease is too advanced for surgical treatment. In carcinoma of the head of the pancreas and especially in carcinoma of the ampulla of Vater, obstruction of the common bile-duct gives rise to jaundice at a comparatively early stage; consequently in these growths a palliative operation is often called for to relieve the jaundice, while occasionally radical extirpation is possible.

As in all operations in the presence of obstructive jaundice, special measures are necessary to reduce the risk of post-operative haemorrhage. Vitamin K should be administered in doses of 10 mg. intramuscularly for two days before operation and a similar period thereafter, while in the course of the operation particular care must be taken to ensure complete haemostasis

Palliative Operations.—To short-circuit the biliary obstruction the

CHAPTER XXIV

OPERATIONS ON THE PANCREAS

Anatomy. Acute Pancreatic Necrosis. Pancreatic Cyst. (the Pancreas. Islet-cell Tumour.

The Pancreas

Anatomy.—The pancreas is deeply placed at the back of the greater part of the gland lying in the epigastrium behind the the tail extends into the left hypochondrium. It is behind the

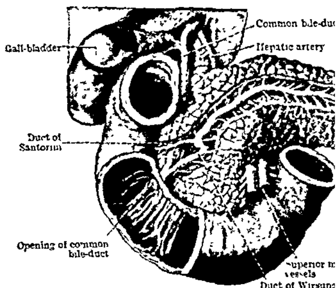


FIG 173 Dissection to show Relations of Gall-Bladder an to Duodenum
(After Spalteholtz.)

lesser sac of which lies directly in front of the gland The head the concavity of the duodenum, the neck crosses the middle li disc between the first and second lumbar vertebrae, and the t spleen The termination of the main duct of the pancreas curves the common bile-duct, which nearly always passes through th

Acute Pancreatic Necrosis.—Acute pancreatic ne often treated conservatively, but operation is called fo gnosis is uncertain.

A right paramedian incision should be made in the upp

Cholecyst-gastrostomy.—The gall-bladder, which is distended with bile, is emptied by means of a trocar and cannula, the trocar being inserted on the inferior aspect close to the fundus at a point suitable for the projected anastomosis.

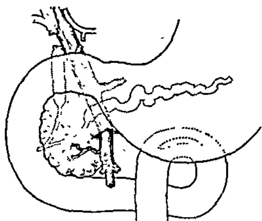


Fig 177. Superior Mesenteric Vein displayed, with large Tributary Vein from Head of Pancreas. Common Duct and Gastro-duodenal Artery divided.

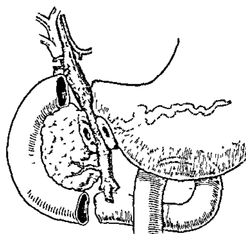


Fig. 178 Duodenum divided in two places. Neck of Pancreas cut across, showing dilated Pancreatic Duct and two Venules entering Portal Vein.

The anterior wall of the stomach in the region of the pyloric antrum is approximated to the gall-bladder and held by stay sutures The anastomosis is then made in the customary manner, using an outer seromuscular continuous suture and an inner suture passing through all the coats of the two viscera. The sutures may be of fine catgut or silk, mounted on an eyeless needle. The stoma should be at least

gall-bladder may be anastomosed to the stomach, the duodenum, or the jejunum. Generally it is satisfactory to use the stomach or duodenum—whichever is more conveniently placed in relation to the gall-bladder. These operations carry a small risk that sooner or later

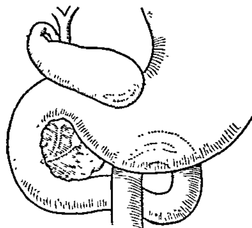


Fig. 175. Cholecyst-gastrostomy and Gastro-jejunostomy performed.

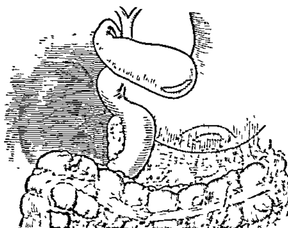


Fig. 176. The Second Operation. Duodenum Mobilized and rolled medially to display Posterior Aspect of Head of Pancreas.

infection may ascend by way of the anastomosis and lead to cholan-[illegible] multiple hepatic abscesses. In malignant disease when the [illegible] ction [illegible] per-formed for non-malignant disease, such as chronic pancreatitis, or as a preliminary to removal of a carcinoma, it is preferable to anastomose the gall-bladder to the jejunum by a technique whereby the risk of infection is diminished.

the neck of the pancreas, and the pyloric end of the stomach are implanted into it, severally and in that order from above downwards. The common duct may be anastomosed to the jejunum by the usual four-layer suture technique or implanted over a rubber tube. The pancreatic duct is intubated and implanted a few centimetres lower, or the whole thickness of the neck of the pancreas may be implanted. The pyloric end of the stomach is inserted a short distance below by the customary end-to-side anastomosis.

The operation involves many technical difficulties and its success depends upon meticulous attention to detail at every step. Leakage of pancreatic juice is a complication especially to be feared. When it occurs, in order to protect the skin from its digestive action, a drain connected with a constant suction pump should be inserted into the wound, or into a sponge-rubber cup applied closely to the surface of the wound. Ephedrine may be given to reduce the volume of the pancreatic secretion, while the loss of fluid and electrolytes (particularly sodium) should be countered by intravenous infusions.

Islet-cell Tumour.—An islet-cell tumour may be suspected in patients with recurring transitory attacks of faintness, giddiness, and nausea accompanied by profound hypoglycaemia. The pancreas is exposed by dividing the gastro-colic omentum. An islet-cell tumour is usually of small size, and may be difficult to find; it can be recognized by its reddish appearance and firm consistence. It has no capsule, and should be excised with a surrounding zone of pancreatic tissue. If the tumour cannot be found, the body and tail of the pancreas should be removed in the hope that subsequent examination of the resected part will disclose a minute tumour. Since the gland is in a healthy state and free from pathological adhesions or infiltration, the operation presents no undue difficulty.

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2·5 cm (1 in) in length. In applying the outer stitch, particular care *is necessary to avoid puncturing the thin-walled gall-bladder.*

Cholecyst-duodenostomy is performed in a similar manner between the inferior surface of the fundus of the gall-bladder and the first part of the duodenum.

Cholecyst-jejunostomy.—A loop of jejunum some 30 cm. (12 in.) from its proximal end may be drawn up in front of the colon and anastomosed to the gall-bladder, entero-anastomosis is then performed between the two limbs of the loop, to divert the intestinal *contents from the gall-bladder anastomosis. A more satisfactory* method is to cut across the jejunum about 15 cm. (6 in.) from the duodeno-jejunal flexure and implant the proximal cut end into the side of the jejunum about 20 cm. (8 in.) farther distally. The blind end is then brought up in front of the colon and anastomosed end-to-end with the fundus of the gall-bladder. Thus a 20-cm. (8-in.) segment of jejunum is interposed between the gall-bladder and the intestinal pathway

Radical Operation —Occasionally it is feasible to resect the head of the pancreas for carcinoma, the duodenum is necessarily removed also since its blood-supply is cut off

The operation may be performed in two stages or at a single session. The latter plan is now usually regarded as preferable While no standard technique has yet been evolved, the general plan of the operation is as follows.

The abdomen is opened through a right paramedian incision. The *right colic flexure is mobilized and displaced downwards.* The duodenum is mobilized by dividing the posterior parietal peritoneum immediately to the right of it and dissected forwards along with the head of the pancreas The pylorus is mobilized after division of the gastro-duodenal artery and the right gastric and gastro-epiploic vessels.

The stomach is divided between clamps immediately proximal to the pylorus. The duodenum is divided in its third part, the distal end being inverted and closed by a purse-string suture.

The common bile-duct is now dissected free, care being taken to avoid damage to the hepatic artery and portal vein, and is divided above the level of the growth. Lastly, the neck of the pancreas is gently freed and cut across, with care to avoid injury to the superior mesenteric vein lying immediately behind it. The duodenum and head of the pancreas together with the terminal portions of the bile and pancreatic ducts can now be removed.

A loop of jejunum, some 15–20 cm. (6–8 in.) below the duodeno-jejunal flexure, is now brought in front of the colon and laid from right to left across the operation field, and the common bile-duct,

tion of the small bowel, due, for example, to a bullet wound or a stab, is closed by means of a purse-string suture which invaginates the aperture and raises the peritoneum over it, or by a Czerny-Lembert suture (p. 346) inserted at right angles to the long axis of the bowel. The whole of the intestine must be carefully examined as bullet wounds frequently cause multiple injuries. Resection of the small intestine should be reserved for cases where multiple perforations are present in a limited segment of bowel or when damage to the mesentery is such as to interfere with the blood-supply to the intestine.

Wounds of the colon are rarely suitable for simple closure, owing to the danger of leakage. The affected segment of colon should be exteriorized and the bowel proximal and distal to the affected segment approximated by serous sutures to form a spur. Later the damaged segment is removed as in a stage resection (p. 434).

Enterotomy.—This procedure consists in opening the small intestine for the removal of a foreign body. The loop of bowel concerned is brought out of the wound and surrounded by gauze packs. If the foreign body is impacted, it should be milked proximally into the distended bowel which is then emptied and lightly clamped. The bowel is opened by a longitudinal incision, the foreign body removed, and the opening closed in the transverse axis with a double tier of sutures.

In the past enterotomy has been employed in cases of intestinal obstruction, with the object of emptying grossly distended intestine. This procedure necessitates considerable handling of the bowel, increases the risk of peritoneal contamination, and offers no advantage over the simpler and safer method of intestinal decompression by a duodenal tube

Enterostomy.—Drainage of the small intestine was formerly employed comparatively frequently for post-operative obstruction, but intestinal decompression by a duodenal tube has replaced to a large extent the need for this operation.

Drainage of the jejunum, jejunostomy, may be required when conservative measures have failed. The procedure is also required occasionally in order to feed a patient when it is necessary to put the stomach at rest in the presence of severe gastric ulceration, or if a gastrostomy is contra-indicated

The abdomen is opened by an incision over the upper part of the left rectus, the duodeno-jejunal junction is identified, a loop of bowel about 30 cm (12 in.) below this point is brought out of the abdomen, and a light clamp applied. A rubber tube or No. 12 rubber catheter is then inserted into the intestine by Witzel's method. The tube is brought to the surface through an opening in the omentum,

CHAPTER XXV

OPERATIONS ON THE INTESTINES

Anatomy. Enterotomy. Enterostomy Ileostomy. Colostomy. Caecostomy. Closure of Faecal Fistula. Visceral Anastomosis. Enterectomy. Colectomy. Acute Intestinal Obstruction.

Anatomy.—The small intestine is arranged in a series of coils filling up the greater part of the abdominal and pelvic cavities, and covered to a variable extent by the great omentum. Individual coils vary in position so much that the only certain means of identifying a particular part of the bowel is by tracing it either from the duodeno-jejunal junction above, or from the caecum below. There is an insensible transition from jejunum to ileum, but if one of the upper coils of the jejunum is compared with one of the lower coils of the ileum, it is found to be larger in calibre and darker in colour, and its walls are thicker because of the greater size and number of the circular folds. These characters are greatly altered in the presence of disease. The duodenum is not visible from the front, being covered by the liver and transverse colon.

Certain parts of the large intestine are liable to vary in shape and position. The transverse colon may descend in front of the small intestine as a V-shaped loop, its apex reaching as low as the symphysis pubis or dipping into the pelvis, and thus increasing the sharpness of the angles at the hepatic and splenic flexures. The caecum, which normally occupies the right iliac fossa, may when distended come to occupy the pelvis, and when provided with a long mesentery may lie in any region of the abdomen, in a case of diaphragmatic hernia the caecum was found in the left pleural cavity The sigmoid flexure or pelvic colon has a well-developed mesentery, and forms a large S- or omega-shaped coil which usually lies in the cavity of the pelvis towards the left side. It may, however, be found in the abdomen proper, and sometimes even on the right side, in the neighbourhood of the caecum, or at a higher level, in the vicinity of the liver. The pelvic colon serves as a receptacle in which solid faeces accumulate; the rectum is normally empty except just before the act of defaecation. The separate bands of longitudinal muscular fibres and the appendices epiploicae constitute a certain means of distinguishing the large from the small intestine; the different parts of the colon can usually be identified by their location, but when there is any doubt, the segment in question should be traced in one or in both directions, the transverse colon is distinguished by having the great omentum attached to it.

The lymph glands in the mesentery of the lower coils of the ileum are those most likely to be infected in such conditions as tuberculosis or typhoid If the infection erupts through the gland capsule, it may involve the visceral peritoneum, and the resulting peritonitis is at first located in the right lower quadrant of the abdomen

Operations on the Intestines

In all operations in which the bowel is opened, the infective nature of the contents must be borne in mind; by careful packing the risk of infection of the cellular planes of the abdominal wall should be reduced to a minimum.

Closure of Perforations, Wounds, and Ruptures.—A perfora-

is in the Trendelenburg position. It is identified by the large number of appendices epiploicae, by the two longitudinal muscular bands directed forward, and by tracing its continuity with the rectum. If the mesentery is short there may be difficulty in finding the colon and in bringing it out at the wound; it may be necessary to enlarge the wound to allow of the colon being mobilized by incising the

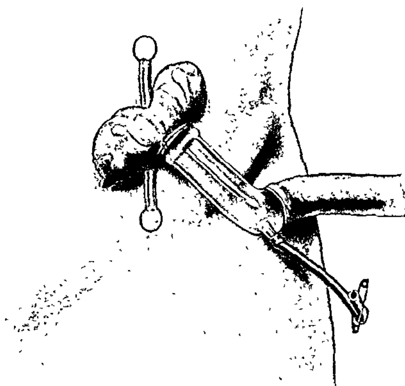


FIG 179 Inguinal Colostomy. A glass rod has been passed through the mesocolon, and a Paul's tube, as modified by Fitzwilliams, has been inserted into the bowel and fixed with a purse-string suture.

peritoneum where it is reflected from the lateral leaf of the mesentery to the parietes

A loop is drawn to the surface and brought out at the wound. Some surgeons lay stress on the necessity of selecting the highest part of the pelvic colon to prevent prolapse of the bowel. We have given up this practice, as the patient is deprived of the use of the pelvic colon as a faecal reservoir, and we have not had any trouble from prolapse. However, if the colostomy is to be followed by excision of the rectum, the upper part of the pelvic colon should be chosen.

or the bowel is sutured to the parietal peritoneum. The stitch holding the tube cuts through in from four to six days and the tube becomes loose, but by this time adhesions have formed which protect the peritoneum. When the tube is removed the fistula tends to close spontaneously.

Jejunostomy for acute intestinal obstruction results in the loss of very large quantities of essential secretions and these must be replaced by a balancing quantity of saline administered intravenously. This loss of intestinal fluid can be avoided by anastomosing the jejunum to the transverse colon (jejuno-transverse colostomy). If the obstruction is due to matting of the intestines by adhesions, the intestines begin to function normally when the distension is relieved and thereafter little will pass through the anastomosis. 'Jejunal diarrhoea' does not occur and subsequent separation of the anastomosis is rarely necessary.

Ileostomy.—This operation is employed when it is desired to place the colon completely at rest, as in some cases of chronic ulcerative colitis or as a preliminary to total colectomy for polyposis of the colon.

The abdomen is opened through a gridiron incision in the right iliac fossa and the terminal ileum brought into the wound. The bowel is doubly clamped and divided at a point about 15 cm. (6 in.) from the ileo-caecal valve. Provided no obstructive lesion is present in the colon the distal end of the ileum is closed, invaginated, and returned to the abdomen. The wound is then closed round the proximal end of the ileum, the parietal peritoneum being sutured to the bowel wall. The clamp may be left in position for twenty-four hours, or removed at once and a rubber tube introduced and secured by a purse-string suture.

Inguinal Colostomy.—This operation consists in making an artificial anus in the pelvic colon, and is most frequently performed to afford relief in cancer of the rectum. It may be done under local anaesthesia.

If the obstructive symptoms call for immediate emptying of the bowel, the operation is completed at one sitting, otherwise it is a great advantage to do it in *two stages*. The first consists in *bringing out a loop of colon and fixing it until adhesions have formed between the visceral and parietal peritoneum*, the second, *in opening the bowel*.

A small opening is made by the gridiron method in the iliac fossa in the same way as is done on the opposite side for removal of the appendix.

If the pelvic colon does not present at the wound, it must be searched for with the fingers, and it is more easily found if the patient

is in the Trendelenburg position. It is identified by the large number of appendices epiploicae, by the two longitudinal muscular bands directed forward, and by tracing its continuity with the rectum. If the mesentery is short there may be difficulty in finding the colon and in bringing it out at the wound; it may be necessary to enlarge the wound to allow of the colon being mobilized by incising the

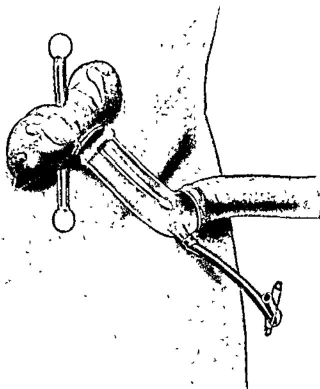


FIG 179 Inguinal Colostomy. A glass rod has been passed through the mesocolon, and a Paul's tube, as modified by Fitzwilliams, has been inserted into the bowel and fixed with a purse-string suture.

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Caecostomy.—The formation of a *permanent* artificial anus in the caecum should be avoided, as the fluid contents cannot be controlled by any form of belt, and being irritating to the skin, cause it to become excoriated and extremely sensitive.

As a *temporary* measure, to tide the patient over the crisis of obstruction, it has much to recommend it; there is the great advantage that the artificial anus is out of the way of the later operation for the removal of the cancer, and, further, that the major operation is made safer by the presence of the artificial anus. Caecostomy, however, may fail to drain the colon efficiently, with the result that when the resection of the growth is undertaken, the risks of infection are increased.

The caecum is exposed through a gridiron incision, and a small Paul's tube or a rubber tube is inserted. On no account must the whole caecum be brought out of the wound as, if this is done, the bowel, deprived of the support of the abdominal wall, will become so distended that its peritoneum may split, and even rupture of all the coats may occur (Stiles). The tube is usually fixed in position by Senn's method (p. 395), and great care must be taken in suturing the bowel, as the caecal wall is often very thin from backward pressure-distension. If the patient's condition permits, a hand is introduced to explore the abdomen and ascertain the exact position of the obstruction in the colon. A 'blind caecostomy' may, however, be performed, and the site of the obstruction discovered later by means of a barium enema and radiography.

Once the tube is removed, the fistula tends to close spontaneously, but if the obstruction has been due to a carcinoma which can be removed, the caecostomy should be retained until after the excision has been carried out (p. 427).

Closure of Faecal Fistula.—When the presence of a spur between the upper and lower openings is responsible for the persistence of a fistula or an artificial anus, and that spur has been deliberately produced at a previous operation, it may be destroyed by crushing it between the blades of an enterotribe (p. 434). In all other cases crushing of the spur is a dangerous procedure: small intestine may be adherent to the region of the spur and be damaged by the enterotribe.

If the fistulous opening is small, it is closed by a dissection and suture operation. An elliptical incision is made round the external aperture, and is carried through the abdominal wall till the peritoneum is reached. The portion of bowel from which the fistula springs is isolated and pulled to the surface, and the internal end of the track snipped away with scissors. The fresh opening in the bowel thus made is repaired by a double tier of sutures of the

There are various methods of securing the loop in position. A simple plan is to choose a bloodless area in the mesentery, transfix it with a pair of forceps, and draw back through the hole thus made (Fig. 179) a glass rod or a piece of thick rubber tubing.

The parietal peritoneum may be drawn through the gap in the mesocolon and sutured to the peritoneum of the opposite side. This procedure is better than suturing the parietal peritoneum to the wall of the colon: such stitches may tear out or cause necrosis.

If the bowel is not to be opened at once, a square of dental rubber, or gauze thickly spread with vaseline, is applied over it to prevent the dressings adhering to the visceral peritoneum.

In the absence of obstruction two or three days are allowed to elapse, but the opening may be deferred for a week or ten days, without detriment. The opening is made slowly with the knife or cautery across the long axis of the gut. No anaesthetic is necessary, as the bowel is insensitive.

The edges of the divided bowel ultimately unite with those of the skin wound; *the protruded portion of bowel shows two openings*, with a septum or spur between them (Fig 194). There is no muscular sphincteric control over the artificial anus thus constituted, but in course of time the bowels come to act periodically at regular intervals, and unless the motions are liquid they are satisfactorily controlled by a cup-shaped pad made of rubber held in position by a belt. These belts become contaminated and are difficult to keep clean, the majority of patients are more comfortable with a simple dressing and binder.

Transverse Colostomy.—This term is employed to designate an artificial anus made in the transverse instead of the pelvic colon. The method is less satisfactory than that of inguinal colostomy, but may be required in cases such as inoperable carcinoma of the descending colon or splenic flexure. Devine advises transverse colostomy, modified in certain particulars, as a preliminary to resection of a carcinoma of the distal colon (p. 435). The abdomen is opened through an upper *left* paramedian incision, the omentum and transverse colon are brought out of the wound, and the further steps are simplified if the omentum is stripped off that portion of the bowel which is to form the colostomy. An incision is made through the posterior layer of the great omentum, where it meets the colon This incision is parallel with and close to the lower border of the bowel, and when completed allows of the easy separation of the omentum from the colon (Lardennois-Pauchet method). The omentum now lies in the upper part of the wound, and the loop of bowel is brought to the surface and fixed in position as in inguinal colostomy.

clamp or between the blades of a triple-bladed clamp, as shown in Fig. 180.

The approximated peritoneal surfaces are united by means of a continuous stitch known as the 'posterior serous suture'. The viscera on each side of the suture line are then opened with a narrow-bladed knife and the incision is enlarged if necessary with scissors, or the serous and muscular coats may be divided with the knife and the mucous and submucous coats with the cautery. It is an additional precaution to divide first only the serous and muscular coats and to

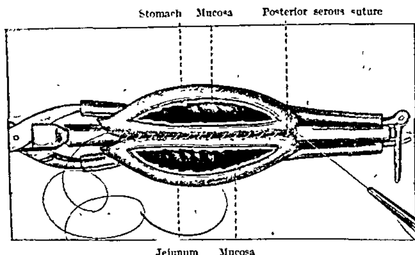


FIG 180 Lateral Anastomosis between Stomach and Intestine (Gastro-enterostomy), 1st Stage.

introduce a second row of sutures, uniting them before dividing the submucous and mucous coats. Any visceral contents are mopped up with small pieces of gauze held in forceps. A continuous suture is then passed through all the coats of both loops, beginning at one end on the posterior surface, and when the other end is reached the same suture is carried along the anterior surface to the starting-point (Figs. 180 and 181) In this way the lumen of the bowel is closed.

To prevent eversion of the mucous membrane along the anterior line of suture the needle may with advantage be used so that it always passes from within outwards.

The viscera are now cleaned with gauze wrung out of saline solution and the clamps removed, if there is bleeding at any point, an additional suture is inserted. The procedure is then completed by approximating the peritoneal surfaces along the front by a continuous Lembert suture—'anterior serous suture'.

Termino-lateral Anastomosis or End-to-Side Junction.—Termino-lateral anastomosis consists in implanting the proximal end

Czerny–Lembert type, after which the bowel is replaced and the abdominal wall repaired in layers, provision being made for drainage of the surface wound.

When the artificial anus is large and implicates a considerable part of the circumference of the gut, it is necessary to resect a segment of bowel, including the fistulous opening. The bacterial content of the faeces may be very materially reduced by the preliminary administration of succinyl sulphathiazole. The protruding mucous membrane is swabbed with pure carbolic acid and the skin edges round it are brought tightly together so as to occlude the opening. The abdomen is then opened, the segment of bowel excised, and an end-to-end or a lateral anastomosis made.

A fistula from the small intestine, if single, may be dealt with as in the case of the colon, but more often there are multiple fistulae and these are associated with matting of the intestinal loops as a result of tuberculous disease of the bowel or of regional ileitis. Under such circumstances local operations to close the fistulae always fail. The abdomen should be opened by an incision placed well away from the infected area, and the ileum proximal to the site of the fistulae is brought to the surface and divided. The distal end is closed and invaginated and the proximal end is anastomosed to the side of the transverse colon (ileo-transverse colostomy with exclusion). This procedure usually results in rapid healing of the fistulae.

Anastomosis between Viscera

In the course of operative procedures on the gastro-intestinal canal, it is frequently necessary to form an artificial junction between two viscera or between two parts of the same viscus, or to re-establish the continuity of the tube. The methods of establishing such anastomoses vary according to circumstances.

Lateral Anastomosis.—The term 'lateral anastomosis' is employed when a side-to-side junction is made between two segments of the alimentary canal This method has to a large extent superseded 'end-to-end' junction in re-establishing the continuity of the divided bowel. It is more easily and rapidly performed, the line of suturing can be more certainly rendered watertight, and it admits of a larger opening of communication being made with less risk of subsequent cicatricial narrowing. It is widely applicable, and is the method of choice for establishing a communication between different segments of the canal, for example, between a coil of intestine above an obstruction and one below—*entero-anastomosis*; between the small and large intestine—*ileo-colostomy*, and between two parts of the colon—*colo-colostomy*.

Each of the two segments to be united is secured in a separate

is rotated sufficiently to bring the serous surface of the ileum into apposition with that of the colon, and they are united by a sero-muscular suture. The transverse colon is now opened by an incision parallel to and 1 cm. (½ in.) from the suture line, the crushing clamp is removed from the ileum, and its lumen opened out (Fig. 183), an occluding clamp having been previously applied to

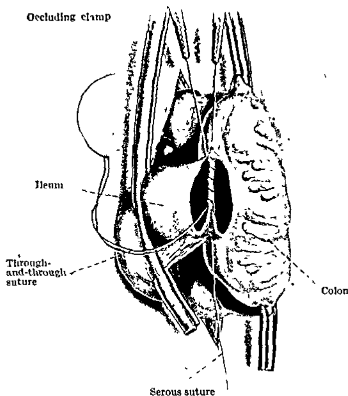


Fig 183 End-to-side Anastomosis by Suture.
The cut end of the ileum is being anastomosed with the colon.

prevent escape of its contents. The anastomosis is then completed as in the case of a lateral anastomosis.

Aseptic Anastomosis.—Under this heading several methods of end-to-end anastomosis have been described. Of these probably the most satisfactory is the procedure described by Schoemaker. It is chiefly employed for the colon, but is also applicable to the small intestine.

At either end of the portion of bowel to be removed, a circular incision is made through the serous and muscular layers, but not through the submucosa and mucosa. The sero-muscular layer is stripped aside to form a cuff (Fig. 184), leaving a tube of mucosa, to which

of a coil of intestine which has been cut across into the lateral aspect of a lower coil. The method may be employed after resection of the terminal ileum and the right half of the colon for carcinoma. In such a case the divided end of the ileum may be anastomosed to

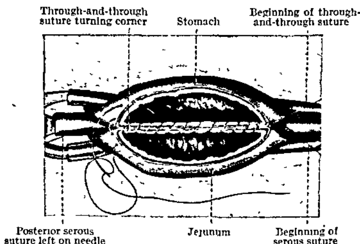


FIG. 181. Lateral Anastomosis, further Stage.

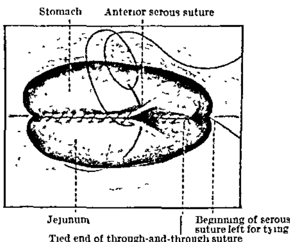


FIG. 182 Lateral Anastomosis almost Completed.

the side of the transverse colon, the divided end of which has been closed—*ileo-transverse-colostomy*

The resection having been completed as described on p. 421, the omentum is raised to expose the under surface of the colon, or it may be stripped off the bowel, which is then controlled by an occluding clamp The end of the ileum, which has been divided distal to a crushing clamp, is approximated to the colon; the clamp

Enterectomy.—When both ends of bowel are to be closed and the canal re-established by lateral anastomosis, we proceed as follows: The portion of bowel to be resected is brought out of the abdomen, and the peritoneal cavity is shut off by the introduction of packs Holes are then made in a bloodless area of the mesentery close to the gut, at the points where the bowel has to be divided. Working from these points the mesentery is ligated and divided towards its base in such a way that a V-shaped portion is isolated. Ligation of the mesentery is best carried out by means of a series of double ligatures,

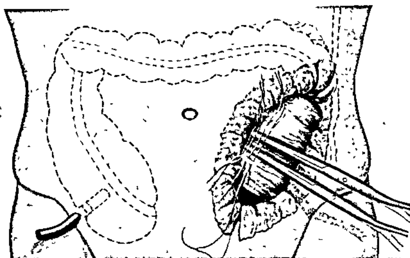


FIG 185. Resection of the Descending Colon for a Malignant Growth.

the two ligatures being tied sufficiently far apart to allow of the vessels being divided between them In this way the use of artery forceps, which tend to obscure the view, is avoided (Fig. 186). The bowel is now emptied of its contents by digital compression, and occluding clamps applied above and below well beyond the limit of the disease. An enterotribe is applied to one end of the loop to be resected, and the bowel is slowly crushed until it is as thin as tissue-paper (Fig 187*a*), the enterotribe is then quickly removed and a catgut ligature tied tightly round the crushed bowel. The procedure is repeated at a distance of some 2 cm. (¾ in.) and the bowel is cut across between the two ligatures with knife or cautery. The other end of the diseased loop is similarly dealt with and the bowel is now free. The next step is the invagination of the stumps of the gut that is to be retained A purse-string suture, of silk, is inserted fully 2 5 cm (1 in) distant from the stump, and the latter,

are applied a pair of special fine clamps. These clamps are ap
together so that when the bowel is divided between them i
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removed, and the two ends, controlled by clamps, are app
in such a way that the posterior serous surfaces (those fart

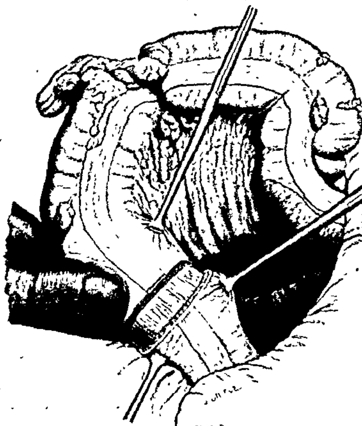


FIG. 184. Resection of Colon. Peritoneal and muscular coats
prior to application of clamps.

the surgeon) can be united by interrupted silk sutures. T
are then rotated so that they lie close together, and the sero
cuffs anteriorly are sutured (Fig 183) When the last stitch
introduced, the clamps are removed, and immediately they
drawn the stitch is tightened and the knot tied. This pr
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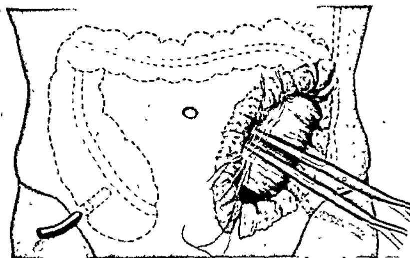


Fig. 185. Resection of the Descending Colon for a Malignant Growth.

Splenic flexure mobilized and brought down, clamps applied to colon after division of the peritoneal and muscular coats, single layer of interrupted silk sutures, posterior row tied, anterior row inserted ready to tie after removal of clamps. Caecostomy to preclude gaseous distension

the two ligatures being tied sufficiently far apart to allow of the vessels being divided between them. In this way the use of artery forceps, which tend to obscure the view, is avoided (Fig. 186). The bowel is now emptied of its contents by digital compression, and occluding clamps applied above and below well beyond the limit of the disease. An enterotribe is applied to one end of the loop to be resected, and the bowel is slowly crushed until it is as thin as tissue-paper (Fig. 187 *a*), the enterotribe is then quickly removed and a catgut ligature tied tightly round the crushed bowel. The procedure is repeated at a distance of some 2 cm. (¾ in.) and the bowel is cut across between the two ligatures with knife or cautery. The other end of the diseased loop is similarly dealt with and the bowel is now free The next step is the invagination of the stumps of the gut that is to be retained A purse-string suture, of silk, is inserted fully 2·5 cm. (1 in) distant from the stump, and the latter,

are applied a pair of special fine clamps. These clamps are applied close together so that when the bowel is divided between them no mucosa projects beyond the clamps. The diseased segment of bowel is now removed, and the two ends, controlled by clamps, are approximated in such a way that the posterior serous surfaces (those farthest from

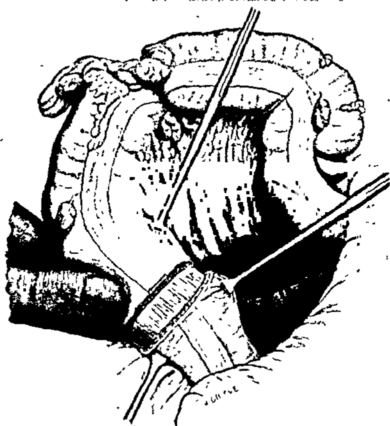


FIG 184. Resection of Colon Peritoneal and muscular coats divided prior to application of clamps

the surgeon) can be united by interrupted silk sutures. The clamps are then rotated so that they lie close together, and the sero-muscular cuffs anteriorly are sutured (Fig. 183) When the last stitch has been introduced, the clamps are removed, and immediately they are withdrawn the stitch is tightened and the knot tied. This procedure is a modification of the one described by Schoemaker, in that only the sero-muscular layers are sutured, but experience has shown that, provided mobilization of the part has been such that there is complete absence of tension at the suture line, the results are eminently satisfactory.

The colon is not so richly supplied with blood as the small intestine, a handicap in repair, and its contents are more infective, so that a

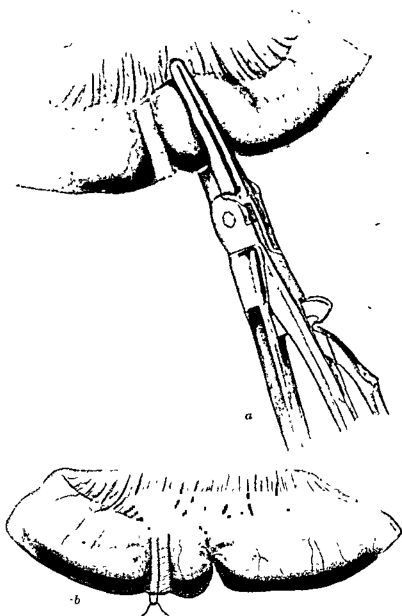


Fig 187. (a) Crushing of the Bowel, a Preliminary Step to its Closure by Ligation.
(b) Closure of the Bowel by Ligation Subsequent to Crushing.

comparatively slight leakage at one of the points of suture, occurring as late as the second or third week after the operation, may cause a slowly spreading infection of the peritoneum which may end in abscess formation, or may spread and prove fatal.

grasped with forceps, is pushed bodily into the lumen beyond the purse-string suture, so that when this is tightened up and knotted the invagination is completed.

The two stumps are then laid alongside each other, iso-peristaltically, and a lateral anastomosis completed as described on p. 418.

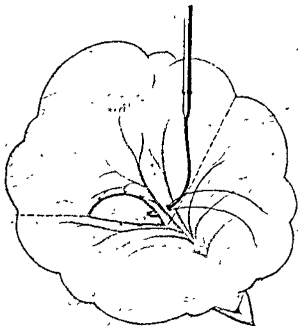


FIG. 186. Enterectomy. Isolation of V-shaped portion of mesentery. Dotted lines indicate the site of division of the bowel.

When the anastomosis is completed, the gap in the mesentery must be closed with sutures, and any adjacent omentum may be used to cover the junction or any surface devoid of peritoneum.

Care must be taken that the bowel is divided where there is an adequate blood-supply, and it is safer to go well beyond the devitalized area, otherwise gangrene and leakage at the suture line may occur. When resection is inadvisable the gangrenous bowel may be brought out and resected later (p 434).

Resection of the Colon. Colectomy.—From the operative point of view the colon differs markedly from the small intestine. Resections of the colon are chiefly performed for cancer, those of the small intestine for gangrene. The mesentery of the lesser bowel is of sufficient length to permit of its being brought outside the abdomen, that of the colon is in many parts so short, or even absent, that the gut must be mobilized to give it the necessary range of movement.

It is still attached by the medial layer of the mesocolon and by the blood-vessels. In this process of mobilization care must be taken of the duodenum on the right side, and of the ureter on both sides.

The Lymphatics of the Colon have been made the subject of special study by Jamieson and Dobson. Groups of lymph glands are found in relation to the different sets of blood-vessels. The ileo-caecal glands are particularly numerous, and there are groups of

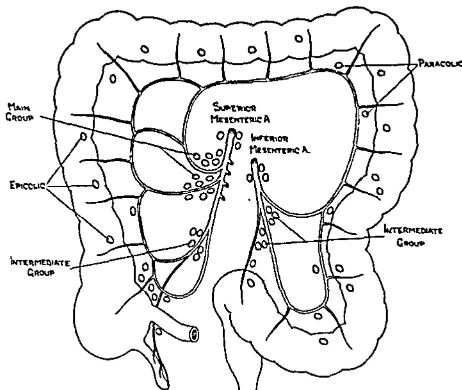


Fig. 189 The Blood-vessels and Lymph Glands of the Colon.

glands also on the anterior and posterior aspects of the caecum. Passing down the colon the glands become less numerous, until they almost disappear in relation to the descending colon; they again become more numerous in the meso-sigmoid. To remove the glands that are liable to be infected, it is necessary to resect the mesentery in which they lie close up to the point at which the corresponding artery arises from the superior mesenteric, and in the case of the branches of the inferior mesenteric, which supply the pelvic colon, up to the origin of that vessel from the aorta. (Fig. 189.)

Resection of the Caecum, Ascending and Right Flexure of the Colon.—This operation has now become established in place of the former limited resections for cancers of the caecum, of the

W. J. Mayo advised that the junction should finally be secured to the parietal peritoneum just beneath the wound in the abdominal wall, and that strips of dental rubber should be carried down to it, so that, in the event of leakage, infective material will readily find its way to the surface. The risks of peritoneal infection can be minimized in a number of ways. The pre-operative administration of sulfasuxidine has a profound effect on the infectivity of

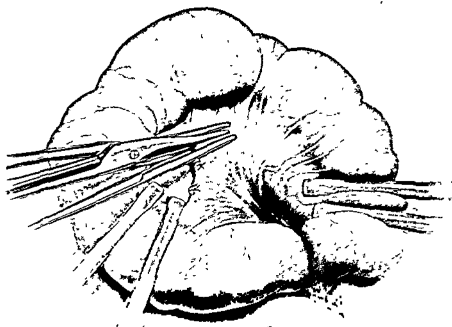


FIG. 188 Resection of the Small Intestine. The bowel is clamped, and the mesentery is being divided.

the bowel, a preliminary defunctioning colostomy as advocated by Devine also lessens the risk of leakage and infection, as does the stage method of resection of the colon.

Mobilization of the Colon.—The practice of mobilizing the fixed parts of the colon has rendered possible a great advance in the surgery of the large intestine. The fixed parts are the ascending and descending portions, the right (hepatic) and left (splenic) flexures, and the iliac colon. To render these parts mobile, the outer layer of the mesocolon—that is, the layer farther away from the umbilicus—is divided parallel with the colon, and by means of the gloved fingers the colon is stripped from the posterior abdominal wall sufficiently freely to admit of its being brought out at the wound.

ascending colon, but the stripping leaves a much larger area uncovered by peritoneum; this should be anticipated and minimized as far as possible by preserving part of the serosa on the lateral aspect of the colon.

The mesentery of the lower 15 or 20 cm. (6 or 8 in.) of the ileum is divided and ligated piecemeal, thereby securing a portion of ileum

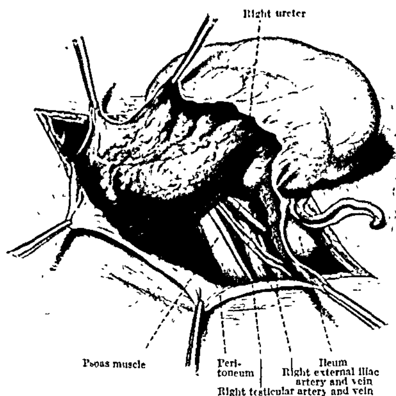


Fig. 190. Mobilization of the Caecum and Ascending Colon.

that will be sufficiently movable to be afterwards joined to any part of the colon.

The caecum, ascending and right flexure of the colon, and the lower ileum are brought out at the wound, and the peritoneal cavity is packed off with gauze. If a side-to-side anastomosis between ileum and transverse colon is to be carried out, the ileum is doubly clamped and divided, and the proximal end closed and invaginated. When the end of the divided ileum is to be anastomosed to the side of the transverse colon, the bowel is doubly clamped and divided flush with the proximal clamp. Owing to its bulk accurate invagination of the stump of the transverse colon is more difficult, but the following method ensures adequate closure The site of division, at the junction of the right with the middle third of the transverse colon,

ascending colon or of the right flexure, not only because it is less likely to be followed by recurrence, but also because it is more reliable and efficient from the technical standpoint.

In the presence of acute intestinal obstruction due to cancer of the caecum, primary resection is not justifiable. In such a case an anastomosis may be made between the ileum and the transverse colon and at a later stage when the obstruction has been relieved, the resection is carried out. Even in the absence of acute obstruction the two-stage method has much to recommend it especially for patients whose general condition is poor.

If the resection is to be carried out in one stage, an oblique incision lateral to the rectus and dividing the external oblique and underlying muscles gives excellent exposure and leaves a strong abdominal wall In the two-stage procedure the abdomen may be explored through an incision over the right rectus, which is displaced laterally, and the resection carried out later through an oblique muscle-dividing incision

The close resemblance which tuberculous disease of the caecum may bear to cancer is to be kept in mind; when there is any doubt, one of the enlarged glands in the mesentery should be removed for immediate examination. If the disease is found to be tuberculous, the choice lies between a resection on similar lines to that for cancer, or, making a short circuit, ileo-colostomy; the former is the ideal method but it may be inadvisable if gross fixation by adhesions renders it difficult and dangerous.

If a radical operation is decided upon, any adherent omentum is divided and ligated piecemeal, and the small intestine is displaced to the left and packed off. Provided that the omentum is not invaded by the disease, the operation is greatly facilitated by a preliminary stripping of the omentum from the transverse colon (p. 426). The caecum, ascending colon, and right flexure are mobilized by dividing the lateral layer of the corresponding mesentery, and the colon and fat are stripped cleanly towards the median line from the muscles of the posterior abdominal wall (Fig. 190), care being taken of the spermatic vessels and vas deferens and of the more medially placed ureter. As the hepatic flexure of the colon is mobilized, the retroperitoneal portion of the duodenum must be recognized lest it be mobilized in error and injured The whole of this procedure can usually be carried out without the necessity for the ligation of vessels. The stripping is continued nearly as far as the origin of the ileo-colic and right colic arteries from the superior mesenteric; the ligation of these vessels about 2·5 cm. (1 in.) from their origin greatly facilitates the further steps of the operation.

The procedure is the same where there is no mesentery to the

ascending colon, but the stripping leaves a much larger area uncovered by peritoneum; this should be anticipated and minimized as far as possible by preserving part of the serosa on the lateral aspect of the colon.

The mesentery of the lower 15 or 20 cm. (6 or 8 in.) of the ileum is divided and ligated piecemeal, thereby securing a portion of ileum

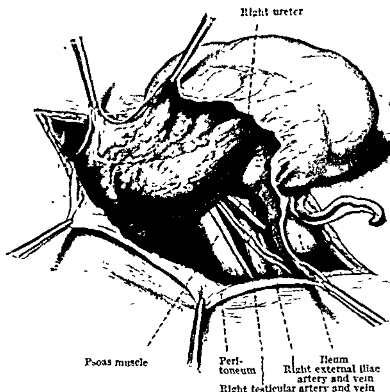


FIG. 190. Mobilization of the Caecum and Ascending Colon.

that will be sufficiently movable to be afterwards joined to any part of the colon

The caecum, ascending and right flexure of the colon, and the lower ileum are brought out at the wound, and the peritoneal cavity is packed off with gauze. If a side-to-side anastomosis between ileum and transverse colon is to be carried out, the ileum is doubly clamped and divided, and the proximal end closed and invaginated. When the end of the divided ileum is to be anastomosed to the side of the transverse colon, the bowel is doubly clamped and divided flush with the proximal clamp. Owing to its bulk accurate invagination of the stump of the transverse colon is more difficult, but the following method ensures adequate closure. The site of division, at the junction of the right with the middle third of the transverse colon,

is put upon the stretch, and the peritoneum and muscular coats are divided all around, leaving a tube of submucous and mucous coats. A catgut or fine linen purse-string suture is inserted in the bowel 2 cm (¾ in.) beyond the cuff, and a strong ligature is tied

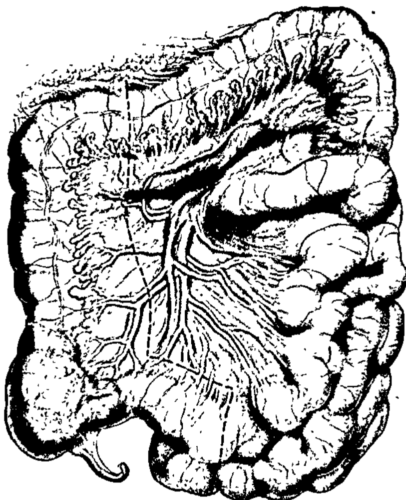


FIG. 191. Extent of Resection in Cancer of Ileo-caecal Segment of Intestine indicated by Dotted Lines

round the denuded portion A clamp is applied proximal to the ligature and the bowel divided with knife or cautery. The stump can then be invaginated and the purse-string tied. The medial layer of the mesocolon is divided on the proximal side of any enlarged glands, and the diseased segment of bowel laid aside.

Communication is now re-established between the ileum and the colon by end-to-side or lateral anastomosis (Fig. 183).

Before the abdomen is closed it is necessary to cover over the area on the posterior abdominal wall that has been deprived of its peritoneum. It may be necessary to mobilize the parietal peritoneum in order that it may be stitched to the divided mesocolon; failing this, the raw surface should be covered with omentum.

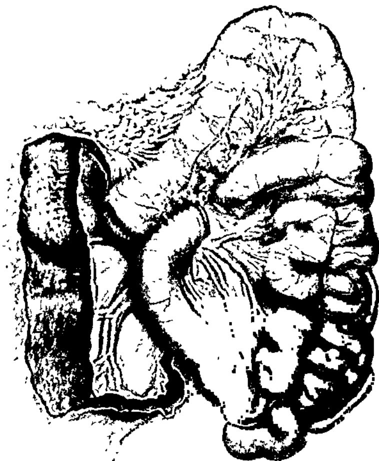


FIG. 192 Lateral Anastomosis between Ileum and Transverse Colon after Resection of Caecum and Ascending Colon for Cancer.

When a tumour in the right half of the colon is found to be unsuitable for removal, a lateral anastomosis between the ileum and transverse colon will give the patient great relief. This is particularly valuable in tumours of the caecum, but when the growth is situated at the hepatic flexure, such an anastomosis leaves the caecum undrained, and its distension with mucus may necessitate the making of a caecal fistula. When possible, an anastomosis between the ascending and transverse colon will overcome this difficulty.

Resection of the Colon beyond the Right (Hepatic) Flexure.

—*In resections involving the middle of the transverse colon*, a relatively limited operation is carried out, which permits of end-to-end union. The gastro-colic ligament is first divided, and the omentum attached to the portion of bowel to be resected is separated from the portions of omentum on either side, and the *middle colic artery*, derived from the superior mesenteric, is ligated. Working from this point, the mesocolon with its glands is separated, the bowel is dealt with as previously described, and the anastomosis completed. Involvement of the greater curvature of the stomach by the carcinoma is not necessarily a contra-indication to operation, as a wedge resection of the affected part of the stomach can be carried out.

In the case of growths of the *left (splenic) flexure*, a portion of the transverse colon and of the descending colon must be removed with the tumour. Resections in this area may be extremely difficult, and the first step is to secure adequate mobilization by division of the peritoneum to the lateral side of the descending colon, and of the costo-colic ligament. Care must be taken not to injure the spleen, but if the tumour is a large one, radical removal can be achieved only if the spleen is mobilized and removed along with the colon, similarly the tail of the pancreas may be excised and its cut surface sutured. The mobilized colon can now be brought out of the wound, the left colic artery, derived from the inferior mesenteric, is exposed and its ascending branch ligated From this point the mesocolon is separated, branches of the middle colic and anastomosing branches of the left colic being secured before division The bowel is now divided and end-to-end union performed. It is essential that the mobilization has been such that there is no tension at the site of anastomosis

To prevent accumulation of gas above the anastomosis with a corresponding lessening of the strain upon the suture line, Stiles advocated the performance of a caecostomy as a final step. In the descending and iliac portions of the colon the steps of the operation correspond very closely with those already described. The whole of the descending colon must be removed, and therefore the main trunk of the left colic artery is ligated.

In the presence of an inoperable tumour of the splenic flexure or descending colon, the symptoms may be relieved by a transverse colostomy. If it is desired to avoid a colostomy, the transverse colon may be anastomosed to the pelvic colon.

Resection of the *pelvic colon*, with complete removal of the lymph tributaries, may necessitate exposure of the inferior mesenteric artery close to its origin from the aorta (Fig 189), but the main vessel should not be ligated, as this entails cutting off the blood-supply to the lower end of the pelvic colon.

The incision is usually made to the left of the middle line and the rectus is displaced laterally, or the incision may be placed farther to the left, corresponding to that described on the right side (p. 428). The extent of the disease is investigated, and this includes examination of the liver for possible metastases. If the conditions permit of a radical operation, it is carried out as follows: the tumour is separated from adherent omentum and pulled out of the wound; the intestines are then packed off with gauze. The parietal peritoneum to the lateral side of the colon is incised, and this incision is carried well upwards so that not only the pelvic but also the descending colon may be freely mobilized. In stripping the colon towards the middle line, which can be done with little or no bleeding, care must be taken of the left ureter which tends to remain adherent to the peritoneum. The inferior mesenteric artery and its first branch, the left colic, are identified, and any glands in this region are stripped downwards. The sigmoid branches of the inferior mesenteric, which are somewhat variable both as regards their origin and number, are then seen. With the exception of the lowest branch which arises just below the level of the promontory of the sacrum, all the sigmoid branches, two or three in number, are ligated close to their points of origin and divided (Fig. 193). The mesentery is then separated in a wedge-shaped manner, anastomosing vessels being secured before division. The bowel is now ready to be dealt with: it is divided between clamps well above and below the tumour and the cut ends are united by circular suture.

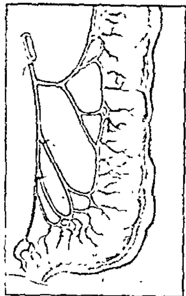


FIG. 193 Resection of Pelvic Colon. Blood-vessels of the distal colon; and points of ligation of the first and second sigmoid branches of the inferior mesenteric artery.

The stitching must be accurate, and special care is taken to ensure perfect apposition at the point where the mesocolon joins the gut. The occluding clamps are removed, the gap in the mesentery is closed, and the bowel is cleansed and returned to the abdomen. An attempt should be made to cover in all raw areas resulting from the mobilization

Two-stage Resection of Colon (Mikulicz and Paul)—If the conditions are unfavourable for resection, and especially if the bowel is loaded, or when the patient is in poor condition and unable to stand the completion of the resection in one stage, this method gives satisfactory results. It has, however, the disadvantage that a second operation is required, and the patient is subjected to a longer convalescence.

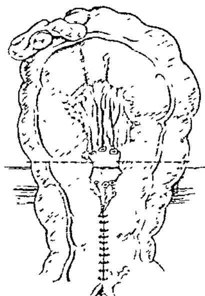


Fig 194.

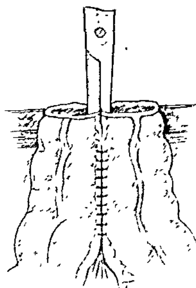


Fig. 195.

Fig 194. Two-stage Resection of Colon.
The diseased loop has been isolated and brought outside the abdomen The proximal and distal limbs have been united Dotted lines indicate the sites of division of the bowel between clamps

Fig. 195 Two-stage Resection of Colon Application of enterotribe to spur.

The first stage consists in opening the abdomen and bringing the segment of colon containing the tumour along with its mesentery and glands out at the wound. If any difficulty is experienced in bringing a loop to the surface, the bowel must be mobilized as previously described. The vessels of the mesentery are now ligated and divided, and the loop containing the tumour thus freed is drawn well out of the abdomen The bowel proximal and distal to the separated loop is now approximated by interrupted serous sutures for a distance of about 8 cm. (3 in.) (Fig. 194); two clamps are applied at either end of the free portion of bowel, which is divided between the clamps and removed. The wound is now closed around the stumps of colon which project above the level of the skin The clamp on the proximal

stump may now be removed and a Paul's tube inserted and secured by a purse-string suture, or when possible, it is better to leave both clamps in position for forty-eight hours, by which time the peritoneal cavity is securely sealed off. The divided ends of the colon now lie side by side, flush with the skin surface and separated by a well-marked spur.

Ten to fourteen days later the spur between the two portions of gut is got rid of by crushing clamp or enterotribe (Fig. 195), the instrument being left in position until the tissue included in its grasp undergoes necrosis and the clamp comes away, which it does usually in five or six days. The spur is rarely completely destroyed by this time and the clamp will have to be reapplied. Once necrosis of the spur is complete, the bowel contents tend to pass into the distal loop and there is considerable tendency for the fistula to close, but further dissection and stitching are usually required to bring this about. The stage resection has been criticized as being an incomplete operation for cancer, but provided a sufficient length of colon is mobilized, a very radical resection is perfectly possible.

Devine has introduced a modification of the stage method of resection for cancer of the distal colon. It is based on the principle that, if a segment of bowel is isolated, its bacterial content will gradually disappear. The first step, therefore, is to disconnect completely the proximal and distal colon. The transverse colon is divided and a spur produced as in Fig. 194, the only difference being that the cut ends of the bowel are brought out through separate openings in the abdominal wall. The isolated distal segment can now be washed out, and after a variable time its bacterial content is reduced to a minimum. When this is attained resection of the growth with primary anastomosis can be undertaken. By this method Devine has found it possible safely to anastomose the sigmoid to the rectum.

Operation for Acute Intestinal Obstruction

When acute obstruction of the bowel has been diagnosed an attempt should be made to determine the cause, as the treatment varies according to the nature of the lesion. In cases of paralytic ileus the treatment should be conservative; strangulation obstructions demand immediate operative relief, while simple mechanical obstructions occupy an intermediate place in that preliminary conservative treatment may be employed to render later operation a simpler and safer procedure. If the possibility of an internal strangulation cannot be excluded with certainty, delay is never justified

If immediate operation is required, the stomach should be washed

Two-stage Resection of Colon (Mikulicz and Paul)—If the conditions are unfavourable for resection, and especially if the bowel is loaded, or when the patient is in poor condition and unable to stand the completion of the resection in one stage, this method gives satisfactory results. It has, however, the disadvantage that a second operation is required, and the patient is subjected to a longer convalescence.

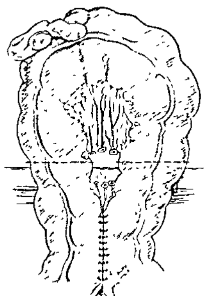


FIG. 194.

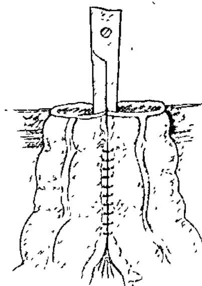


FIG. 195.

FIG 194. Two-stage Resection of Colon.
The diseased loop has been isolated and brought outside the abdomen The proximal and distal limbs have been united Dotted lines indicate the sites of division of the bowel between clamps

FIG. 195. Two-stage Resection of Colon. Application of enterotribe to spur.

The first stage consists in opening the abdomen and bringing the *segment of colon containing the tumour along with its mesentery* and glands out at the wound. If any difficulty is experienced in bringing a loop to the surface, the bowel must be mobilized as previously described. The vessels of the mesentery are now ligated and divided, and the loop containing the tumour thus freed is drawn well out of the abdomen. The bowel proximal and distal to the separated loop [illegible] ance of [illegible] end of [illegible] ps and [illegible] removed. The wound is now closed around the stumps of colon which project above the level of the skin. The clamp on the proximal

obstruction to be expected may be obtained by noting whether distended small or large intestine presents in the wound and whether the bowel is inflamed and lymph-covered or shows signs of venous congestion. It must be kept in mind that a volvulus of the pelvic colon may, when grossly distended, present in the right iliac fossa and be mistaken for a distended caecum. The nature of the peritoneal exudate may also prove helpful. Marked intestinal distension is usually associated with the presence of a clear peritoneal exudate. If the obstruction is due to a strangulation or mesenteric thrombosis a blood-stained exudate will escape from the wound. In advanced cases the fluid may give the typical odour of *Bacillus coli*.

To Find the Cause of Obstruction.—For purposes of exploration the incision should be large enough to admit the hand, but should grasp the wrist so that the abdominal contents do not escape. In many cases such an intra-abdominal exploration may not be sufficient and it will then be necessary to enlarge the incision. The exploration should proceed systematically, beginning with the caecal region. If the caecum is distended, the presumption is that the obstruction is lower in the colon and the gut should be traced downwards as far as the lower end of the pelvic colon, the commonest site for a malignant stricture. If the caecum is collapsed, the terminal portion of ileum, probably collapsed also, should be secured and traced upwards until distended bowel is encountered, the cause of the obstruction being found at the point where they meet.

If the obstruction is due to adhesions or bands, these are most likely to be met with in the right iliac fossa following, for example, appendicitis, or in the pelvis in the case of women, the result of previous inflammatory affections of the pelvic organs. The internal hernial openings may be found to be the site of the obstruction, even although no evidence of a strangulated hernia had been found at the previous clinical examination. Such an error in diagnosis is most likely when a small knuckle of bowel is engaged in the inguinal, femoral, or other opening and the patient is very stout, the increased [illegible]

testinal

in one

of the various intraperitoneal fossae, it may be extremely difficult or impossible clearly to visualize the obstructing agent. In such circumstances the incision must be enlarged and it may be necessary to bring the intestines out of the abdomen. As this procedure adds to the shock of the operation and increases the danger of the development of paralytic ileus, great care must be taken to see that the bowel is kept protected and warm with hot moist towels.

To Remove the Cause of Obstruction.—When the search is

out, a duodenal tube left in position, and continuous suction established. The bladder should be emptied and intravenous infusion of saline commenced and continued throughout the operation. When operation can be delayed with safety, some hours may be spent in combating dehydration and alkalosis, which are always present to a greater or lesser degree, by the administration of intravenous saline. The volume required may amount to many litres and can be estimated by plasma chloride estimations or more simply and with reasonable clinical accuracy by testing the urine with 2·9 per cent silver nitrate using 20 per cent. potassium dichromate as an indicator. The test is carried out as follows. With a pipette 10 drops of urine are placed in a test-tube and 1 drop of 20 per cent. potassium dichromate is added, giving a clear yellow colour. The pipette is washed out and 2·9 per cent. silver nitrate is added drop by drop until an orange-red precipitate is obtained and persists after shaking. The number of drops of silver nitrate required to produce this colour change approximates to the number of grammes of chloride per litre of urine. Thus 3 drops of silver nitrate corresponding to 3 grammes of chloride in the urine would indicate that a satisfactory chloride balance had been achieved

The need for replenishment of the liver glycogen is met by giving glucose with the saline, or as 6 per cent. glucose in sterile water if the chloride balance has been stabilized. At the same time continuous gastric suction to effect intestinal decompression is essential The ideal method is to pass a Miller-Abbot tube by stages into the duodenum and jejunum, applying suction the while, but this procedure is often difficult to accomplish and sometimes impossible. In most cases simple gastric suction by means of a syphonage apparatus or intermittently with a syringe achieves good results. This suction must be maintained throughout the operation and for several days thereafter

The choice of anaesthetic is important, but must depend on the condition of the patient. Spinal anaesthesia is ideal, provided the blood-pressure is not too low, as it gives perfect relaxation, minimizes the tendency for distended loops of bowel to escape from the abdomen, and encourages intestinal contractions once the obstruction has been relieved

If the general condition of the patient is poor, local anaesthesia may be employed, but as these operations are fraught with difficulty, the ease of intra-abdominal manipulation afforded by gas and oxygen anaesthesia probably makes it the method of choice.

If, as is usual, the exact site of the obstruction is in doubt, the incision is made below the umbilicus, usually through the medial edge of the right rectus muscle Information as to the type of

Volvulus usually affects the pelvic colon and is a serious form of obstruction as gangrene is liable to occur rapidly. The bowel is so distended that when the abdomen is opened there is a grave risk of the bowel wall giving way; to prevent this the loop must not be brought outside the abdomen. It is usually necessary to empty the bowel before the twist can be undone and it is often possible after the abdomen has been opened, with one hand inside, to guide a tube passed from the rectum into the distended loop and so withdraw its contents. If this fails the peritoneum is packed off, a small cannula attached to a suction apparatus is inserted into the bowel, the contents aspirated, and the twist may then be undone. A temporary colostomy may be established or the bowel may be exteriorized and resected later. Resection, either immediately or better later, has the advantage that it appears to be the only method of treatment which permits of recovery without the danger of recurrence. Volvulus of the caecum is also met with and is dealt with on similar lines.

Volvulus of the small intestine is by no means uncommon. It may be associated with adhesions or a band situated just distal to the rotated segment. Such predisposing causes should be looked for and if possible removed. If a long segment of intestine is involved its release may be difficult. In such cases it is much better to enlarge the wound so that the nature of the rotation can be clearly seen and its reduction facilitated, if necessary bringing the rotated bowel outside the abdomen into warm towels.

When the obstruction is due to impaction of a gall-stone or a foreign body it will usually be found in the lower ileum. An occluding clamp is applied to the bowel which is opened, preferably just above the point of impaction, the obstructing agent is removed, and the opening closed by two rows of sutures in the transverse axis. If the patient's condition permits, the proximal bowel should be examined as a second foreign body may be present. The writer has removed a straw-ball causing obstruction and found a second equally large mass lying in the distended intestine at a higher level.

When the symptoms of acute obstruction have suddenly supervened on those of the chronic form, and a *tumour is found occluding* the colon, colostomy or caecostomy should be performed in the first instance, and, if the growth is removable, it can be dealt with later (p. 417).

Acute Obstruction Following Operation.—Acute intestinal obstruction may follow closely upon any abdominal exploration but most commonly after an operation for acute appendicitis with peritonitis, intestinal resections, or pelvic operations. The cause may be due to intestinal ileus, probably the result of overaction of the sympathetic nerve-supply to the bowel. Operation is not required as

successful, steps are taken to remove the cause of the obstruction. If this proves to be a *fibrous band* or an adherent *process of omentum*, the two ends of the constricting agent should be defined if possible, caught with artery forceps, and divided. After the band is removed the ends are secured by catgut ligatures. As a matter of fact the band often gives way during the exploration by the fingers without its having been seen. If the bowel is viable, it is returned to its place in the abdomen; if not, it is resected (p. 423), unless the gangrenous area be small, in which case it may be invaginated by a series of Lembert sutures. If the condition of the patient is grave, immediate resection and anastomosis may not be justified. In such a case exteriorization and enterostomy should be performed and the continuity of the intestine established at a later stage. If a *Meckel's diverticulum*, or an *appendix adherent by its tip* is acting as a band, the proximal end is crushed with a clamp, sterilized with pure carbolic acid, and buried by Lembert sutures, after the distal portion has been removed.

Congenital openings in the mesentery may ensnare a loop of bowel or the obstruction may be due to some form of *internal hernia*, the bowel having passed into one of the intraperitoneal fossae which are met with in relation to the duodenum and caecum. In such cases important vessels may lie in relation to the constriction ring, for example the inferior mesenteric vein lies as a close anterior relation of the neck of the left paraduodenal hernia. Great care must be taken if the constriction ring has to be divided to permit of reduction of the hernia.

When adhesions have so kinked or matted the intestinal coils as to interfere with the passage of their contents, no attempt should be made to separate the adherent portions of bowel. Such attempts are liable to result in damage to the bowel, and in any case the adhesions will re-form An entero-anastomosis or an anastomosis between the ileum and the transverse colon, according to the site of the adherent bowel, is a much safer and more satisfactory procedure.

When *the obstruction is due to intussusception, the invagination* can usually be reduced by exerting steady pressure on the apex of the *intussusception so as to push it out of its sheath*. This manipulation must be carried out entirely within the abdomen, but it may be necessary to bring the bowel into the wound to complete the last phase of the reduction, which often presents difficulty. The apex is surrounded with warm, moist towels and reduction completed by exerting firm pressure for a few minutes. On no account should the entering layer be pulled upon as this involves the risk of tearing the bowel.

If the intussusception is irreducible and the whole is found to be gangrenous, the affected segment must be resected or exteriorized.

CHAPTER XXVI

OPERATIONS ON THE VERMIFORM APPENDIX

Anatomy. Appendicectomy. Interval Operation. Incisions. Removal of Appendix. After-treatment. Emergency Operation. Operation for Appendicitis with Abscess.

Anatomy.—The vermiform appendix arises from the postero-medial aspect of the caecum about 2 cm. (¾ in.) below the ileo-caecal junction. The origin of the appendix from the caecum is most accurately represented on the surface by a point at the junction of the lateral and middle thirds of a line joining the anterior superior iliac spines Being fixed to the caecum (itself a movable organ) only at its base, and being provided with a mesentery, the appendix enjoys a comparatively wide range of movement, so that its position in the abdominal cavity varies. The three commonest situations of the appendix are: (1) curling upwards and medially from the caecum, under cover of the

rotate, the appendix may lie in the left iliac fossa, in the right hypochondrium, or in other abnormal situations.

varies in length, in some cases extending to the tip of the organ, in others terminating about its middle; it is sometimes so short that the appendix is fused with the caecum, while in the retro-caecal type the mesentery can rarely be identified. In many cases a short avascular and often fat-laden fold of

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small glands near its base, and from them the efferent vessels pass to the mesocolic glands behind the ascending colon.

Removal of the Vermiform Appendix—Appendicectomy

The Interval Operation.—The removal of the appendix between attacks—the 'interval operation'—was introduced by Treves in 1887.

Incision —The incision should be chosen to suit the individual case The gridiron incision of McBurney and Roux, or Lanz's modification, does not weaken the abdominal wall and is rarely followed by herniation, but has the disadvantage of affording somewhat limited exposure. The pararectal incision of Battle gives

intestinal decompression by gastric or duodenal suction, maintenance of water balance and blood chemistry, and rest to the bowel by giving frequent small doses of morphine may be expected to relieve the condition. In other cases the obstruction is the result of adjacent coils of bowel becoming matted together by lymph. Operation may be required, but very often conservative treatment as for paralytic ileus will relieve the condition as the adhesions are of recent origin, and if gross distension is prevented, the intestine adjusts itself to the altered conditions. It must be remembered that paralytic ileus may occur apart from operation, a notable example being its occurrence following fracture of the spine.

K. P. B.

of the skin incision; or downwards by carrying the incision through the rectus sheath. In so doing, care must be taken to avoid damage to the nerves supplying the rectus muscle, or to the inferior epigastric vessels.

Lanz has suggested a modification of the gridiron incision, which he claims gives better access and leaves a less noticeable scar. The incision (Fig. 197 *c*) begins close to the anterior iliac spine and passes



FIG. 197. Incisions for Exposure of the Vermiform Appendix.
a Incision through sheath of rectus (Battle) *b* Incision of McBurney and Roux *c* Lanz's incision

medially and slightly downwards in the natural skin crease. The deeper dissection is similar to that above described.

In the *pararectal incision* of Battle (Fig. 197 *a*) the skin is incised parallel, and about 1·5 cm. (½ in.) medial, to the lateral border of the rectus muscle. The anterior sheath of the rectus is divided in the same line, and the lateral border of the muscle is defined, freed from its sheath, and retracted medially. The nerves passing medially to the mobilized segment of muscle are defined and preserved, and care is taken to avoid injury to the inferior epigastric vessels, which pass upwards and medially on the deep aspect of the muscle. The fascia transversalis and the peritoneum are then picked up and incised in the same line as the skin wound.

The *paramedian incision* is a vertical incision 1·5 cm. (½ in.) to the right of the midline below the umbilicus. The anterior sheath of

better views but is somewhat more liable to hernia. In cases where the diagnosis is uncertain or where exploration of the lower abdomen

umbilicus to the right anterior superior spine. If clinical examination

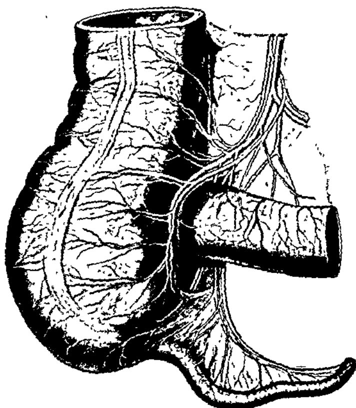


FIG. 196 Normal Caecum and Vermiform Appendix

suggests that the appendix is abnormally high or low, the incision may be modified accordingly.

The external oblique aponeurosis is split in the direction of its fibres and retracted to expose the internal oblique muscle and, more medially, the anterior rectus sheath. The internal oblique and transversus muscles are also split in the line of their fibres—at this

the underlying viscera.

If the gridiron incision is found to afford insufficient access, it may be enlarged upwards by cutting across the deeper muscles in the line

divided as far as the base of the appendix. A purse-string suture of fine catgut or silk is then introduced through the wall of the caecum, down to the dense submucous coat, around the base of the appendix (Fig. 199).

The next step is to ligate the base of the appendix with catgut; if it is thick, the diameter of the wall may be diminished by crushing with a clamp, or a cuff of the peritoneal coat may be reflected to form a bed for the ligature. Before the appendix is cut across, a pair of

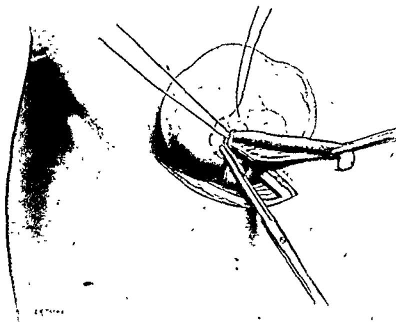


FIG. 199. Removal of the Vermiform Appendix, 2nd stage.

forceps is applied distal to the ligature to prevent leakage of contents. The ligated stump is cauterized with a drop of pure carbolic acid, invaginated into the caecum, and buried by tightening the purse-string suture. To make the sealing more secure, an additional sero-muscular suture may be introduced, or the 'avascular fold' of Treves may be tacked down over the invaginated stump. The caecum is then returned to the abdomen.

Before closing the abdomen, the parts within reach should be examined, particular attention being paid to the female pelvic organs, to the lower coils of the ileum, and to the ileo-caecal lymph glands.

Closure of the Wound.—If the gridiron incision has been employed, the peritoneum is closed by a continuous suture of fine catgut, and each of the layers of the abdominal wall is separately sutured.

the rectus is divided in the same line, the muscle is retracted laterally, and the posterior sheath and peritoneum divided.

Exposure and Removal of the Appendix.—In the absence of adhesions a normally placed appendix is easily removed.

The first step is to identify the caecum and to bring it to the surface. The index finger is inserted into the peritoneal cavity towards the

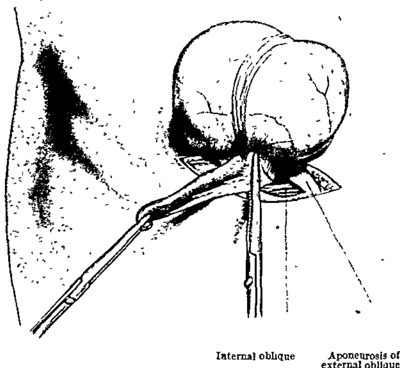


Fig. 198 Removal of the Vermiform Appendix, 1st Stage.

right side and then medially to hook up the caecum, which is recognized by its sacculation and its longitudinal muscular bands. By tracing the anterior longitudinal band downwards the appendix is reached. In visceroptotic persons the transverse colon may present, when the caecum must be sought lower in the right iliac fossa or in the pelvis.

To bring the appendix up to the wound it may be necessary to divide peritoneal bands or adhesions · as they are almost bloodless they may be separated by blunt dissection or by scissors Separation should be carried out until only the meso-appendix remains. By putting the meso-appendix on the stretch, the appendicular artery is identified; it is then clamped (Fig 198), and the meso-appendix

determined by gentle palpation. If a peri-appendicular abscess is opened into, the pus is swabbed out or aspirated before proceeding farther.

The caecum is then identified and drawn towards the wound, and the appendix is mobilized by the separation of any inflammatory adhesions around it. This part of the operation should, if possible, be conducted under direct vision, to avoid the risk of rupturing the appendix, or of damaging adjacent intestine. Especial care is necessary when the appendix is obstructed and distended with faecal pus, or if it is semi-gangrenous and on the point of perforating. If the omentum is adherent over the appendix, it should not be separated, but should be ligated and divided at a convenient distance.

The appendix is then removed as in the interval operation (p. 444) and the stump buried by means of a purse-string suture, or, if the caecal wall is greatly thickened or oedematous, by a few interrupted sero-muscular sutures.

If delivery of the tip of the appendix proves difficult, it may be advisable to deal first with the base before proceeding to separate the distal part of the organ (*retrograde removal*). The meso-appendix and its vessels are ligated and divided, the base of the appendix is ligated, divided, and carbolized, and the stump invaginated. The appendix is then traced to its tip and removed.

Drainage of the Peritoneal Cavity.—It is now recognized that the peritoneum is able to cope with a considerable amount of residual infection, provided the primary focus is removed, and consequently in the early stages of acute appendicitis drainage is unnecessary. If, however, there is extensive peritonitis, if an obstructed appendix has ruptured into the free peritoneal cavity, or if there is a localized abscess cavity, it is usually advisable to drain.

In most cases the drain may be inserted through the original wound, but sometimes it is advisable to make a stab wound in the midline above the pubes for this purpose. The most satisfactory drainage material is thin sheet-rubber, rolled loosely. To avoid constriction, the part of the drain that traverses the abdominal wall should be enclosed in a short cylinder of stiff rubber tubing. The main drain should extend downwards towards the pelvis: if there is marked retro-caecal infection a second drain should be passed in this direction.

Closure of the Wound.—Even in cases in which the [illegible] is not drained, if there is any [illegible] wall has become contaminate [illegible] rubber dam at one end of the wound to drain the muscular planes, as the muscular and areolar tissues show little resistance to the spread of infection.

If the pararectal incision has been employed, after closing the peritoneum and the fascia transversalis with a continuous catgut suture, the rectus muscle is allowed to resume its normal position, and the wound in its anterior sheath is closed with continuous or interrupted sutures. Care must be taken to include the internal oblique aponeurosis, which on the lateral aspect of the wound tends to retract out of sight.

After-treatment—Very little after-treatment is required. If the patient complains of flatulent pains on the second day, a flatus enema (glycerine 1 ounce, Henry's solution 1 ounce, and water 2 ounces; or turpentine ½ ounce to a pint of soap and water) should be given. The bowels are moved on the morning of the third day by castor oil or other mild purgative, followed, if necessary, by a soap-and-water enema. The stitches are removed on the eighth or ninth day. Formerly it was usual to keep the patient in bed for ten to fourteen days, but in many cases this is excessive. A young or middle-aged patient may be allowed up on the third day or even earlier, particularly if a gridiron incision has been used

The Emergency Operation.—The incision must be planned so as to afford free access to the appendicular region, and to provide for efficient drainage should this be found necessary. At an early stage in the attack of appendicitis the gridiron or the pararectal incision may be used. At a later stage the access they provide is sometimes too restricted.

The method of approach designed by Kocher has advantages when the appendix is believed to be retro-caecal or retro-colic. The skin and the external oblique aponeurosis are incised obliquely, as in the gridiron operation, and the incision is carried in the same line through the deeper muscles, cutting across their fibres, and through the fascia transversalis and the peritoneum, in the same direction. This incision [illegible] of free [illegible] coils [illegible] The division of the deeper muscles is not found to lead to any undue weakness of the resulting scar

When the pre-operative diagnosis is uncertain, an incision in or near the middle line may be considered, but this should be avoided if possible as it entails the risk of disseminating infection from the appendix to other parts of the peritoneal cavity.

Exposure and Removal of the Appendix—The peritoneal cavity having been opened, a moist gauze roll is inserted to pack off the small intestine and pelvis, and so obviate the spread of infection during the subsequent manipulations.

The position of the appendix and the extent of the disease are

Post-operative Complications.—*Secondary or Residual Abscess.* If, after temporary improvement, the temperature begins to rise and the patient ceases to improve, the wound should be examined, and if no focus of suppuration is found there, an examination of the pelvis and of the subphrenic region should be made for evidence of abscess formation.

Persistence of a *sinus* for some weeks suggests the presence of a foreign body,—unabsorbed catgut, concretion, etc.—, of tuberculous disease, or of actinomycosis.

A *faecal fistula* usually heals spontaneously, but it may become necessary to close it by operation (p. 417).

Intestinal obstruction may result from toxic paralysis of the intestine (paralytic ileus) or from constriction by a band or adhesion. The former is the more usual cause in the early, the latter in the later, phase of the post-operative period. The treatment is described in Chapter XXI. If these means fail to give relief, enterostomy should be performed (p. 413).

C. F. W. I.

When gross contamination of the wound has been unavoidable, and especially if there is much fat in the abdominal wall, free drainage is necessary. A few interrupted sutures of catgut are inserted to approximate the edges of the peritoneum. Strong, interrupted sutures of silkworm gut are inserted through the skin at one side of the wound, applied to the muscle layers in figure-of-eight fashion, and brought to the surface on the same side (Fig. 200).

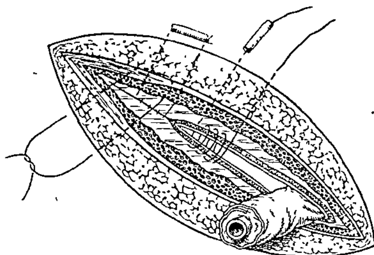


FIG. 200 Method of using 'looped sutures' of silkworm gut in place of catgut for closure of deeper layers of wounds.
(After Wilkie)

The skin and subcutaneous tissue are left unsutured, and the wound is loosely packed with gauze wrung out of eusol or Dakin's solution. Secondary suture is carried out later, when the infection has been overcome.

Operation for Localized Appendicular Abscess.—When there is evidence that a large circumscribed abscess has formed around the appendix, it is generally advisable to drain the abscess in the first instance, and to remove the appendix some weeks later.

A short oblique skin incision is made (Fig 197*b*) over the most salient part of the swelling, and the muscles are divided in the same line, exposing the peritoneum. In incising the peritoneum, care is taken not to injure any viscus that may be adherent to it, or to open into the general peritoneal cavity. After the abscess has been evacuated, a large-bore rubber drainage tube is inserted.

If the abscess is retro-caecal it may be exposed through a similar skin incision by an extra-peritoneal route, by blunt dissection to the lateral side of the peritoneal cavity.

four of which are specially well marked, and as they contain a quantity of submucous and muscular tissue at their bases, they constitute distinct and permanent valves—the *horizontal folds*—which sometimes interfere with the passage of instruments.

The submucous connective tissue is specially loose, and in it run the blood-vessels, lymphatics, and nerves. The muscular coat is made up of an outer series of longitudinal fibres, the downward continuation of the three longitudinal bands of the colon, and an inner series of circular fibres. At the junction of the

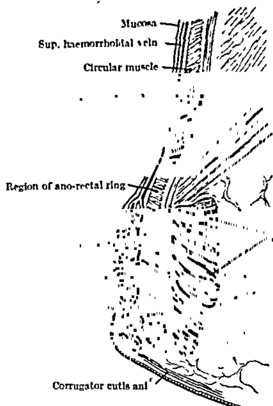


FIG 201. Anatomy of Anal Canal and Rectum.

rectum and the anal canal, a bundle of muscular fibres, termed the recto-urethralis, connects the muscular coat of the rectum to the structures in front, namely [illegible]

pathetic through the upper three or four lumbar nerves.

The *superior rectal artery*, the continuation of the inferior mesenteric into the pelvis, is the principal artery of the rectum. The terminal twigs run down in the submucous layer as far as the upper part of the anal canal where they supply the pile-bearing area. The *middle rectal artery* arises from the internal iliac It is a small vessel and supplies the muscular coat. The *inferior rectal artery* arises from the internal pudendal; it crosses the upper part of the ischio-rectal fossa and supplies the sphincters and the anal canal. It may anastomose

CHAPTER XXVII

OPERATIONS ON THE RECTUM

Anatomy. Incisions. Abscesses. Fistulae. Haemorrhoids. Prolapse of the Rectum. Malignant Disease.

Anatomy.—The lower portion of the intestinal tract is divided into the *anal canal*, which extends upwards from the margin of the true skin for a distance of about 3 cm. (1¼ in.), and the *rectum proper*, extending from the upper limit *of the anal canal to the level at which the peritoneum is reflected from the* bowel, which is usually opposite the body of the third sacral vertebra. Above this level is the *pelvic colon*

Anal Canal (Fig. 201).—The skin around the anal orifice is pigmented, and is thrown into folds by the contraction of the external sphincter muscle. It contains numerous sudoriparous and sebaceous glands, and hair follicles. In its lower part the anal canal is lined by modified skin continuous with that around its orifice, and in its upper part by mucous membrane similar to that of the rectum proper. The muco-cutaneous junction is marked by a fine wavy line from which thickened processes of mucous membrane pass upwards, forming the *anal columns* Between the lower ends of these columns stretch a series of short semilunar valves, the *anal valves*, behind which are small crypts —the *anal sinuses*

The *external sphincter* is made up of three parts, the *subcutaneous, superficial,* and *deep* The *subcutaneous external sphincter* is an annular muscle which ... and the anal orifice. It is about 0 5

he lower border of the
ch is part of the lower
ctum The *superficial*

external sphincter is an elliptical muscle lying between the subcutaneous and the deep external sphincters Posteriorly it arises from the dorsal surface of the coccyx and the anococcygeal body. The fibres pass forwards on each side of the anal canal surrounding the middle and lower part of the internal sphincter.

the coccyx. In front some of the fibres pass to the opposite ...
to the ramus of the ischium, while other fibres become connected with the perineal body.

... of the circular muscular fibres
ounded by the deep and
border is separated from
the subcutaneous external sphincter by the anal intermuscular septum.

The ano-rectal ring is a composite fibromuscular band at the junction of the anal canal and the rectum. It is made up of the upper portion of the internal sphincter, the longitudinal muscular layer, the puborectalis portions of the *levator ani* which form a sling round the bowel at this level, and the deep ... external sphincter

(3 in.) in length, and is lined by a thick,
by columnar epithelium, and containing
numerous *tubular* mucin-secreting glands and follicles of lymphoid tissue. In the upper part the mucous membrane is arranged in horizontal folds, three or

in the trench with new material' (W. E. Miles). It is necessary to excise the skin widely, not only at the margins of the opened-up track but beyond the external opening so as to ensure adequate drainage and to make certain that the part of the wound which extends into the anal canal will be healed before healing is complete in the external wound. The shape of the track varies with its relation to the anal canal; when the external opening lies in relation to the anterior half of the canal, the track tends to be direct; when the external opening is in relation to the posterior half, the track is usually horseshoe-shaped, the internal opening lying in the middle line posteriorly and the external opening to one side, the original abscess having been deflected to one side by the attachment of the external sphincter to the coccyx. In some cases there are multiple external openings. The best classification of fistula is that of Milligan and Morgan into subcutaneous, submucous, anal, and ano-rectal (Fig 202).

Subcutaneous Fistula.—In this variety the track lies superficial to the sphincter muscles, the external opening lying close to the anus and the internal within the anal canal. A probe or probe-pointed director is passed along the track and the track laid open. Sufficient skin is cut away from the margins of the opened-out track and beyond its external opening to leave an open shallow wound with no overhanging skin edges. A dressing of gauze soaked in eusol is tucked lightly into the wound.

Submucous Fistula.—A submucous fistula or 'sinus' lies in the submucous layer of the anal canal and may extend into the rectum. The track can be recognized by the finger as a line of induration. The external sphincter is dilated and a probe passed along the track. The overlying mucosa is divided with a diathermy knife, or it may be divided between two pairs of artery forceps with knife or scissors, the tissues in the bite of the forceps being transfixed and ligated in order to guard against haemorrhage.

Anal Fistula.—In the common variety of anal fistula—'low level'—the internal opening is situated between the subcutaneous portion of the external sphincter and the lower border of the internal sphincter at the level of the anal intermuscular septum. In the less common form—the 'high level'—the internal opening is usually situated in the upper part of the anal canal just below the ano-rectal ring in the posterior segment. In this variety great care must be exercised to avoid permanent damage to the sphincter with resulting incontinence.

In the *low-level anal fistula* the treatment is similar to that of the subcutaneous form, the subcutaneous external sphincter being divided with the other tissues overlying the track. It is essential

with the middle rectal artery. The veins of the rectum correspond to the arteries. The superior rectal vein begins in the internal haemorrhoidal plexus which lies in the submucous layer of the upper part of the anal canal. It becomes continuous above with the inferior mesenteric vein and therefore belongs to the portal system. The external haemorrhoidal plexus lies under the skin of the anal margin. It drains upwards into the internal haemorrhoidal plexus as well as into the inferior rectal veins.

The *lymph vessels* drain mainly into glands alongside the two divisions of the superior rectal artery. These are embedded in the peri-rectal fat between the muscular coat and the fascia propria. The lymph from the lower part of the rectum passes partly to the internal and external iliac glands. The lymphatics from the lower part of the anal canal and peri-anal region pass to the inguinal glands.

Incisions in the Region of the Rectum and Anal Canal.—The ideal to be aimed at is to leave a wound which is widely open and relatively shallow so that perfect external drainage will take place Where the anal canal is involved as well as the adjacent skin, it is desirable that healing should be complete inside the bowel before external healing takes place, so as to guard against the possibility of fissure. To bring about these results it is necessary to excise considerable portions of skin; where the anal canal is involved this is done in a triangular or pear-shaped manner with the broader end away from the bowel, so that healing may take place more quickly at the central end than at the other In dealing with abscess and fistula the wound must be 'saucerized' by cutting away large segments of skin The wounds left after such excision of skin may appear unduly large but healing takes place rapidly.

Ano-rectal Abscesses.—Ano-rectal abscesses are described as peri-anal, ischio-rectal, submucous, and pelvi-rectal according to their anatomical position The *peri-anal* and *ischio-rectal* abscesses are opened by a cruciate incision, extending to the limits of the abscess in each direction. Each of the four skin flaps thus outlined is partly excised so as to ensure free external drainage The *submucous* abscess may heal spontaneously, but, if not, it may continue to discharge indefinitely owing to the opening being too small to provide for proper drainage. The sphincter should be dilated, the opening of the abscess found and dilated with forceps, and a drainage tube fixed in the abscess cavity with a stitch, the tube being brought out through the anus A *pelvi-rectal* abscess is opened in the same way as an ischio-rectal. A drainage tube should be passed through the opening in the levator ani, part of the muscle being divided if necessary. The tube is fixed in position with a stitch.

Fistula in Ano.—In order to bring about healing of a fistula the entire track must be laid freely open. The treatment is comparable to 'the conversion of a subterranean tunnel into an open trench by digging away the earth covering it from end to end and then filling

track to the ano-rectal ring cannot definitely be decided, it is safer to operate in two stages. At the first stage the external part of the fistula is laid open, the subcutaneous sphincter divided, and sufficient skin cut away to provide for drainage. In two weeks' time, when the muscles have become bound down by new fibrous tissue during the preliminary healing and are unlikely to retract, the inner part of the track may be opened up by dividing the remainder of the overlying muscle. Under no circumstances must the ano-rectal ring be completely divided.

Ano-rectal Fistula.—In the ano-rectal fistula the main track extends above the ano-rectal ring. There may be an internal opening into the rectum itself or the track may be 'blind' with an external opening only. As it is not possible to divide the ano-rectal ring, the ano-rectal fistula cannot be converted into a flat wound in the usual way. It is necessary to be content with guttering the track and this is best done posteriorly towards the coccyx. With a finger in the anal canal to guard the musculature, the track is laid widely open and the skin floor of the ischio-rectal fossa is liberally removed, especially in the backward direction towards the coccyx. This leaves a wide funnel-shaped wound which will fill up with granulation tissue.

Operations for Haemorrhoids

External Haemorrhoids.—The type of external haemorrhoid which gives rise to acute symptoms is due to rupture of a peri-anal vein. This results in a haematoma which forms a tense bluish swelling at the anal margin, and which becomes acutely painful. Under local anaesthesia the swelling should be split into two halves with scissors, the blood clot expressed, and the whole of the undermined skin cut away. More skin should be removed from the outer than from the inner end of the wound, so that the resulting wound is pear-shaped with the broad end away from the anus.

The other type of external haemorrhoid consists of thickened skin tags, often the legacy of the acute variety. If operative treatment is necessary, it is carried out by removal under local anaesthesia on the same lines as above, care being taken to leave a triangular or pear-shaped wound.

Internal Haemorrhoids.—The patient is anaesthetized and placed in the lithotomy position. In this position the three primary haemorrhoids are left lateral, right posterior, and right anterior, or at 3, 7, and 11 o'clock. The external sphincter is gently stretched and the three haemorrhoids are grasped with artery forceps near their upper end. The left lateral haemorrhoid is most conveniently dealt with first. The forceps holding the pile is taken in the palm of the left hand, the left index finger in the anal canal applying pressure

that the probe or director should be passed along the whole length of the track into the bowel without perforation of the wall of the track, and that all communicating pockets or channels be freely opened up.

In the *high-level anal fistula* a probe is passed along the main track from without into the anal canal and is felt to lie just below the ano-

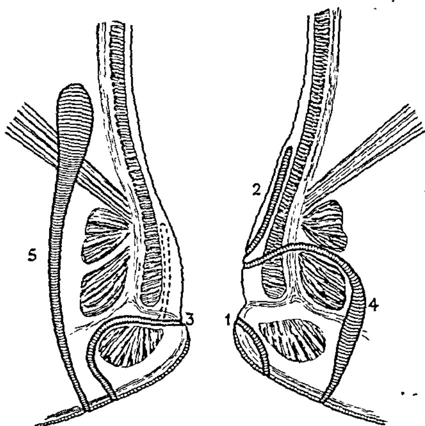


FIG. 202 Fistula-in-ano.
1 Subcutaneous 2 Submucous 3. Anal fistula (low level) 4 Anal fistula (high level). 5 Ano-rectal

rectal ring, some muscle forming the ring being definitely felt above the probe. The tissues lying over the probe, including a large bundle of muscle, are now divided and the track laid freely open. It is probable that the muscles divided include the subcutaneous, the superficial, and part of the deep external sphincter, as well as the related parts of the internal sphincter and the longitudinal muscle. The pubo-rectalis and some intimately attached fibres of the deep external sphincter and the longitudinal muscle are left intact, forming the complete ano-rectal ring. So long as this is the case, there need be no fear of incontinence. If the relationship of the

track to the ano-rectal ring cannot definitely be decided, it is safer to operate in two stages. At the first stage the external part of the fistula is laid open, the subcutaneous sphincter divided, and sufficient skin cut away to provide for drainage. In two weeks' time, when the muscles have become bound down by new fibrous tissue during the preliminary healing and are unlikely to retract, the inner part of the track may be opened up by dividing the remainder of the overlying muscle. Under no circumstances must the ano-rectal ring be completely divided.

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outwards at the level of the subcutaneous external sphincter. A second pair of artery forceps is now applied to the skin at the site of the corresponding external haemorrhoid. This forceps is also placed in the palm of the hand. A V-shaped cut is made with scissors so as to outline the skin over the external haemorrhoid. Starting at the apex of the V, the tissues are dissected medially from the underlying subcutaneous external sphincter until the attachment of the longitudinal muscle is reached. The haemorrhoid now swings free on its pedicle, which consists of rectal mucosa, a branch of the superior rectal artery and vein, and a part of the longitudinal muscle. The pedicle is transfixed with a stout catgut suture and the ligature tied tightly with the knot towards the lumen. The pile is cut away at least 1·5 cm ($\frac{1}{2}$ in.) distal to the ligature; it is necessary to keep well below the ligature so as to obviate any risk of slipping. The right anterior and the right posterior piles are then dealt with in the same way. Care must be taken to leave intact at least 0·25 cm. of anal mucous membrane and skin between the wounds of adjacent haemorrhoids to guard against the possibility of stricture. If a prominent secondary haemorrhoid is left, it is seized with artery forceps and a shallow incision made with scissors at its lower border; a catgut ligature is then tightly applied.

Treatment by Injection.—If piles of the first and second degree are soft and vascular, they respond well to treatment by injection. This method has the great advantage that the patient does not require to lie up and is able to carry on with his normal work It is not suitable for tough fibrous piles of long standing, or for third-degree prolapsing piles. The solution employed is a 5 per cent. solution of phenol in almond oil The injection is made at the upper limit of the pile and the effect is to bring about a shrinkage and retraction of the pile as a result of the irritant action of the carbolic acid

Technique —An illuminated rectal speculum, a 5 c.c. syringe, and a needle long enough to reach beyond the speculum are required. The syringe and the solution must be warmed. The patient lies in the left lateral position with the knees bent well up. The speculum is passed to the full distance and then withdrawn until the pedicle of the selected haemorrhoid is exposed Two to three cubic centimetres of the solution are injected into the pedicle, the speculum being withdrawn a little to allow the solution to spread downwards. A similar quantity is injected into another haemorrhoid. The same procedure is carried out at intervals of seven days, until all the haemorrhoids have been treated

Secondary Haemorrhage —This is a rare but troublesome complication after operation for haemorrhoids. It may be controlled by

the method described by Lockhart-Mummery (Fig. 203). A piece of sterilized rubber tubing about 10 cm. (4 in.) long and 1 cm. (½ in.) in diameter is taken, and round one half of this a strip of dry gauze is wrapped so as to increase its diameter by about three times. The gauze is smeared with vaseline and, under pentothal anaesthesia, a wide proctoscope is passed into the rectum. The tube with the gauze-

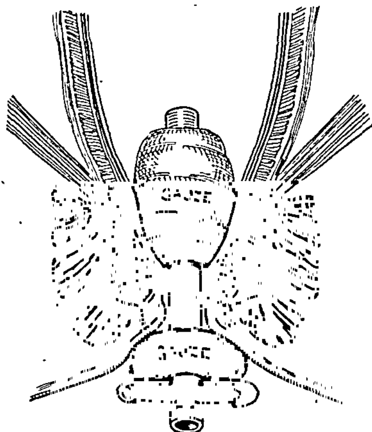


Fig 203 Means of Controlling Haemorrhage after Operation for Haemorrhoids

covered end upwards is passed through the proctoscope with the help of pressure by dissecting forceps, first on one side and then on the other. The speculum is withdrawn and the lower end of the tube pulled upon so as to bring the gauze-covered portion against the bleeding surface. A large safety-pin is next passed through the tube about 1 cm (½ in.) away from the anus. A gauze strip is wound round the tube between the safety-pin and the anus in order to exert pressure on the pile-bearing area The tube and gauze should be removed in forty-eight hours

Anal Fissure.—In the chronic forms of anal fissure which require

operative treatment there is a well-marked sentinel pile and considerable induration of the floor of the ulcer. The fissure lies over the subcutaneous external sphincter and is usually situated in the middle line posteriorly, rarely in the middle line in front. To ensure healing of the fissure it is necessary to remove an area of peri-anal skin so that two-thirds of the wound will lie outside the anal canal and only one-third inside With the patient in the lithotomy position a triangle of skin is marked out with a scalpel, with the apex at the site of the fissure and with sides measuring 3 to 3·5 cm. ($1\frac{1}{4}$–$1\frac{1}{2}$ in.). The skin is dissected up with scissors towards the anus At the apex of the triangle the sentinel pile and then the fissure are removed. The subcutaneous external sphincter is then divided at the site of the fissure so that the finger can be passed into the anal canal without the least hindrance. A dressing of vaseline gauze is applied to the wound and a corner of the gauze is tucked into the anal canal.

Prolapse of the Rectum.—The treatment depends on the age and general condition of the patient and on the degree of the prolapse In children operative treatment is seldom required. In exceptional cases linear cauterization may be carried out in order to produce adhesions between the mucous and muscular coats. The prolapse is drawn down with forceps and three or four longitudinal lines are made in the bowel wall with a Paquelin cautery heated to a dull-red heat. Care must be taken not to make the burns too deep, and the middle line of the anterior aspect of the bowel should be avoided so as to obviate any risk of damage to the related peritoneum.

In adults the treatment depends on whether the prolapse is partial or complete In cases of *partial prolapse* a satisfactory result may be obtained by an operation on the same lines as for removal of haemorrhoids (p. 455). An artery forceps is applied to the redundant mucous membrane in the position of each of the three primary haemorrhoids. Each segment is freed by scissor cuts at the muco-cutaneous junction and on each side transfixed and ligated and removed. Narrow strips of intact mucosa should be left between the segments removed.

The treatment of *complete prolapse* is unsatisfactory, as is indicated by the large number of operations which have been devised for the treatment of the condition.

Lockhart-Mummery's Operation —The rectum is packed with gauze to avoid leakage during the operation A transverse incision 8 cm. ($3\frac{1}{2}$ in.) long is made midway between the anal orifice and the tip of the coccyx The external sphincter is freed from the tip of the coccyx and the space between the rectum and the sacrum freely opened up by finger dissection The separation should be carried upwards for a distance equal to the length of the prolapse when down, and should also be carried round the sides of the rectum so that as wide an area

as possible may become adherent. The space behind and on each side of the rectum is lightly packed with vaseline gauze, the object being to prevent primary union between the rectum and the walls of the pelvis. Tight packing must be avoided owing to the risk of necrosis of the wall of the rectum. The wound is closed over the gauze, the end of which is secured in one of the stitches. At the end of a week an anaesthetic is administered and the gauze removed. The wound is irrigated and re-packed. The gauze should not be entirely removed for fourteen days. The patient is kept in bed for four weeks. An aperient is given on the seventh day.

Amputation of the Prolapse.—The patient is placed in the lithotomy position and the head of the table slightly lowered so that the small intestine may fall away from the pelvis. A circular incision is made through the outer layer of the prolapse immediately beyond the muco-cutaneous junction. The mucous membrane is divided first and the divided tissues washed with an antiseptic lotion. The peritoneal cavity is opened in front by dividing the muscular and serous coats. The margin of the opening is freed for a short distance and is sutured to the serous coat of the exposed bowel. The wound is extended first to one side and then to the other, serous sutures being inserted immediately after each cut. Next the division of the outer layer is completed on the posterior aspect, and the inner layer of the protrusion is divided. The divided inner and outer layers are then sewn together, first by a series of interrupted sutures taking a stout bite in the tissues, and then by a continuous catgut suture to approximate the edges of the mucous membrane.

OPERATIONS FOR MALIGNANT DISEASE

Choice of Method.—Wide surgical removal of the affected segment of bowel and of the associated lymphatic field still affords the best hope of cure in carcinoma of the rectum. The types of operation may be subdivided into those in which the operation is carried out entirely from below (perineal operation), and those in which it is performed partly from the perineal and partly from the abdominal aspect (combined operation). The perineal operation is less severe, but it permits of only a limited removal, and is feasible only in tumours involving the middle and lower thirds of the rectum. The perineal operation may be done in two stages in elderly patients who are poor subjects for operation. The method of choice is a one-stage perineo-abdominal operation on the lines advocated by Gabriel. A preliminary colostomy may be required in order to get the bowel properly emptied before the major procedure is carried out, but Gabriel has shown that this is hardly ever necessary and that the bowel can be emptied by simple medical measures. Instead of being

beneficial, a preliminary colostomy is actually harmful, as the patient's general condition deteriorates during the period of confinement to bed between the two operations and the faecal fistula contaminates the abdominal wall and adds to the technical difficulties and dangers of the major procedure.

Methods have been devised which permit of conservation of the sphincters and union of the two divided ends of the bowel. It may be said that, except in certain very early cases, these are attended with risk of recurrence because of too limited a resection.

Perineo-abdominal Operation.—The patient requires about a week's preparation. The bowel is gradually emptied by the administration of liquid paraffin and mild laxatives. The rectum is washed out every second day, the last wash-out being given on the evening before operation

Spinal anaesthesia is administered, preceded by a small dose of pentothal This is supplemented by general anaesthesia with cyclopropane which is very light in the earlier stages of the operation but which requires to be deepened towards the end of the abdominal stage In the male, a rubber catheter is passed and fixed in position by strapping, after the bladder has been emptied the catheter must be clipped to prevent the entrance of air. A long right paramedian incision is made extending from 2 5 cm. (1 in.) above the umbilicus to the pubis The abdomen is explored to determine whether the growth is operable or not, the pelvic peritoneum, the liver, and the great omentum being carefully examined as well as the growth itself. If the case is operable, the wound is closed temporarily with through-and-through sutures of silkworm gut and covered with a sterile dressing The patient is then placed in the exaggerated lithotomy position with a flat sandbag under the pelvis. The anus is closed by a stout encircling suture of linen thread. An elliptical incision is made around the anus and about 2 cm. ($\frac{3}{4}$ in.) away from it. The incision is carried upwards over the coccyx and inclines to one side of the middle line over the lower end of the sacrum. An oblique incision probably causes less pain after operation than one exactly in the middle line The coccyx is exposed and removed, the sacrococcygeal joint being found by pressing the tip of the coccyx well forwards. The middle sacral artery is usually divided during removal of the bone, it is difficult to ligate, but the bleeding is easily controlled by gauze pressure. The parietal layer of the pelvic fascia in front of the bed of the coccyx is divided, and the rectum, enclosed in its fascial sheath, is exposed The finger can now be passed forwards on the upper surface of the levator ani muscle. The fat of the ischiorectal fossa is incised on one side and the inferior rectal vessels secured. The levator ani muscle is then divided with scissors from

behind forwards, the finger above the muscle acting as a guide. The division is carried forwards to within about 1·5 cm. (½ in.) of the middle line. This procedure is repeated on the other side. The



Fig 204 Excision of Rectum for Carcinoma. Division of Levator Ani (After Gabriel) (Inset. Line of incision.)

separation of the structures in front of the anal canal is the most difficult part of the operation and care must be taken to avoid injury to the urethra in front and the bowel behind. The perineal body is divided with scissors and the anal canal can be drawn a little back.

rectal vessels are divided in the substance of the fascia. The rectum can then be stripped up posteriorly almost to the sacral promontory.

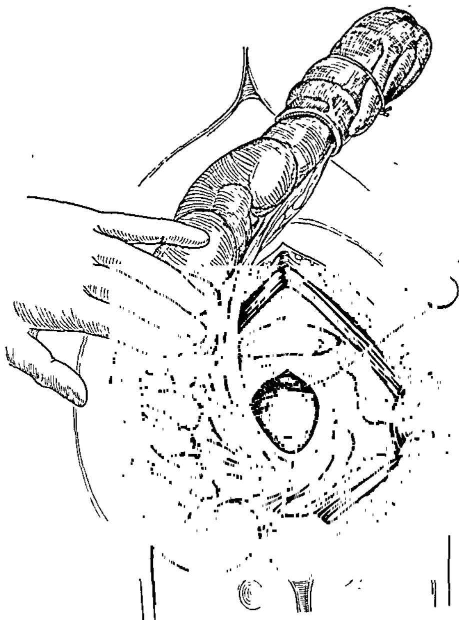


Fig 206 Excision of Rectum for Carcinoma. (After Gabriel.)

Mobilized rectum and pelvic colon delivered through right paramedian subumbilical incision Pelvic floor being sutured from below upwards. Dotted line shows upward extension of peritoneal incision required on right side at base of pelvic meso-colon.

The bowel can now be brought well down and the peritoneal reflection can be identified on its anterior aspect. Care should be taken in the

The puborectal fibres of the levator ani form stout strap-like bundles on each side of the middle line and these are divided with scissors, cutting from the lateral side towards the middle line. The recto-urethralis is also divided. By working from one side towards the median plane the line of cleavage between the prostate and bladder

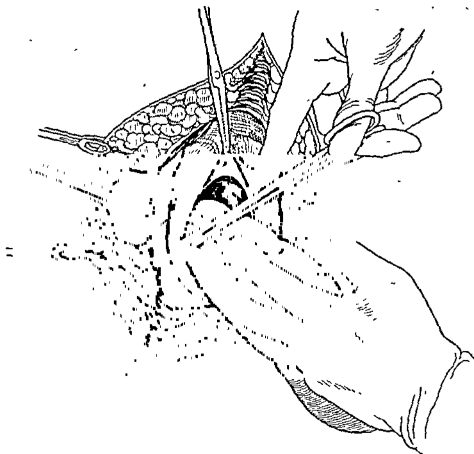


FIG 205. Excision of Rectum for Carcinoma. (After Gabriel.)
Conclusion of perineal stage of operation Peritoneal pouch opened anteriorly. Prostate exposed Peritoneum being incised upwards on each side of recto-sigmoid

in front and the rectum behind (Denonvillier's space) can generally be entered. If not, the separation can be facilitated by thrusting a blunt artery forceps upwards and backwards in the middle line parallel to the anterior surface of the rectum The blades of the instrument are separated, and this generally opens up Denonvillier's space. The bowel is then easily separated from the structures in front At this stage the descent of the rectum is hindered by fascial bands passing from the side wall of the pelvis to the rectum. These must be divided freely on each side and towards the back. The middle

tubing is passed into the proximal end of the colon and fixed with a suture. If the perineal wound has not been previously packed, the patient is turned on his side and the packing inserted. The anterior part of the perineal wound is brought together with silkworm gut sutures.

As soon as the patient is back in bed, he is given 500 c.c. of blood intravenously. This is followed by the administration of glucose and saline for the first forty-eight hours after operation. The catheter is left in the bladder for five days. If normal micturition is delayed, regular catheterization must be continued. Sulphathiazole, 0·5 gm., is given thrice daily as a urinary antiseptic. The gauze pack in the perineal wound is partly removed on the second day and the remainder on the third day after the operation. The perineal wound heals by granulation, and it generally takes about three months before healing is complete. The patient is usually able to get out of bed on the twelfth or fourteenth day after operation.

The Perineal Operation.—A preliminary colostomy is performed two or three weeks previously. Spinal anaesthesia is administered, and the patient is placed either in the exaggerated lithotomy position or in the prone inverted V position with the head and feet low and the buttocks uppermost. The earlier steps in the operation are the same as those described in the perineal stage of the perineo-abdominal operation up to the point where the peritoneum is opened (p. 462). When the peritoneum has been divided freely upwards on each side of the rectum, the lower end of the pelvic colon comes into view. In order to complete the delivery of the rectum, it is necessary to divide the superior rectal vessels as they lie in the lower part of the pelvic mesocolon. The vessels can be isolated by working the forefinger through the mesocolon between the vessels and the bowel. They are ligated by a stout catgut ligature passed with an aneurysm needle. After division of the vessels, the entire rectum can be brought down into the wound The peritoneum is closed by suturing it around the pelvic colon some distance above its lower end. The line of section of the bowel should be made, if possible, through the pelvic colon and not through the thick muscular wall of the rectum, which is difficult to close satisfactorily. A purse-string suture of catgut is passed round the the bowel 2 cm. above the line of section. A groove is cut in the muscular coat and a catgut ligature tied tightly in the groove, which permits it to bite. The bowel is divided between the ligature and a clamp. The ligated stump is then invaginated and the purse-string suture tied. The large cavity is lined with oiled silk and packed with gauze. The anterior part of the wound is brought together with deep sutures of silkworm gut, the posterior part being freely left open.

male that the bladder is stripped well upwards so that there may be no danger of mistaking a fold of bladder wall for the peritoneum. The membrane having been identified, it is opened in front of the rectum and divided upwards on each side of the bowel to as high a level as possible. The lower part of the mobilized rectum is now enclosed in a sterile rubber glove, this being tied tightly round the bowel by a stout ligature. The rectum enclosed in the glove is then pushed well up into the pelvis through the opening in the peritoneum. The perineal wound may now be lined with oiled silk, packed with gauze, and the anterior part of the wound closed with silkworm gut sutures, or a temporary pack may be placed in the wound and the closure deferred until the end of the operation. A small sterile towel is fixed to the skin with silkworm gut sutures so as to cover the wound completely.

The patient is now placed in a moderate Trendelenburg position. The abdominal wound is reopened and the small intestine packed into the upper abdomen. The mobilized portion of the rectum enclosed in the rubber glove presents in the pelvis. The lateral incision in the peritoneum is continued upwards on each side of the attachment of the pelvic mesocolon. The whole lower bowel can then be stripped up from the posterior wall of the pelvis and delivered into the wound. The inferior mesenteric artery is identified and a ligature passed around it between either the first and second or the second and third sigmoid branches The vessel is then divided between forceps and an additional ligature applied to the proximal end. The mesocolon is divided at this level from its base as far as the marginal artery. A gridiron incision about 10 cm. (4 in) long is made in the left iliac fossa, the internal oblique and transversus being divided at right angles to their fibres in the lower part of the wound. The rectum and pelvic colon are then passed through this wound and carefully placed on the abdominal towels so that they do not hang down.

The pelvic floor is now repaired by closing the peritoneum with a catgut suture carried from the base of the bladder up to the level of the divided mesenteric artery, this is carried out in a straight line in the antero-posterior direction. One of the special advantages of the perineo-abdominal method is that the pelvis is empty at this stage of the operation and it is easy to make a sound closure of the peritoneum. The paramedian incision in the abdominal wall is now closed. The peritoneum in the left iliac incision is sutured around the emerging intestine The muscular layers are brought together by interrupted catgut sutures, care being taken not to stitch the external oblique too tightly. The mesocolon is divided about 4 cm. (1½ in.) outside the wound, and the colon divided at the same level between clamps. To facilitate the early passage of flatus, a piece of rubber

CHAPTER XXVIII

OPERATIONS FOR HERNIA

Inguinal: Anatomy. 'Radical Cure.' Irreducible. Sliding. Strangulated. Femoral: Anatomy. 'Radical Cure.' 'Strangulated. Umbilical: 'Radical Cure.' Strangulated. Ventral: 'Radical Cure'.

OPERATIONS FOR INGUINAL HERNIA

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the pubic crest. In the adult the canal is about 4 cm. (1½ in.) in length and is directed medially with a slight inclination downwards and forwards. In the [illegible]

inguinal ligament. The posterior wall is formed by the fascia transversalis, together with the conjoint tendon at its medial part. The floor of the canal is formed by the inguinal ligament and its pectineal reflection to the body of the pubis. The roof is formed by the arching fibres of the internal oblique and transversus muscles which span the contents obliquely. It is to be specially noted that the anterior wall is weakest at the superficial ring, the posterior wall at the deep ring.

The coverings of an oblique inguinal hernia, from without inwards, are the skin, the external spermatic fascia derived from the aponeurosis of the external oblique, the cremasteric fascia and cremaster muscle continuous with the internal oblique, the internal spermatic fascia representing the fascia transversalis, the extraperitoneal tissue and the peritoneum which constitutes the sac.

Herniotomy for Inguinal Hernia.—*'The Operation for Radical Cure.'*—Within recent years the operative treatment of hernia has been greatly standardized by the general recognition that the essential factor in effecting a permanent cure is the removal of the sac from the inguinal canal with the minimum of trauma, the obliteration of its neck at its highest part, the repair of the stretched fascia transversalis at the deep ring, and a post-operative régime which combines avoidance of stress with graded exercises to assist in the functional recovery of the inguinal mechanism. Of primary importance is the early submission of patients to operation while the rupture is still small and the secondary changes in the canal are remediable.

In the case of larger and recurrent hernias and those where the abdominal musculature has lost its tone, it is now generally recognized that they constitute a separate problem requiring in addition to the removal of the sac a plastic operation appropriate to the particular case, designed to reinforce the posterior wall of the inguinal canal.

The Abdomino-perineal Operation.—In the procedure described by Miles, the abdominal stage is performed first. If the condition is found to be operable, as high a point on the pelvic colon is chosen as will allow the proximal segment to be brought to the skin without tension. At this point the bowel is divided between clamps, and both ends are invaginated. The mesocolon is divided to its attachment, and the inferior mesenteric vessels are divided between ligatures. From this point incisions are carried distally *through the peritoneum close to each side of the mesocolon, then* parallel to the rectum to the pelvic floor where they join in front of the rectum. The distal part of the bowel is drawn forwards and freed; posteriorly down to the level of the sacro-coccygeal joint, laterally by division of the lateral ligaments, and in front from the bladder and prostate or from the vaginal wall. The mobilized bowel is packed into the pelvis, the divided end being left near the end of the sacrum The gap in the peritoneum is closed, if necessary with the aid of a flap from the posterior aspect of the bladder, or of flaps from the broad ligaments. The proximal end of the pelvic colon is brought to the surface through a small gridiron incision in the left iliac region, and the abdominal cavity is closed.

The perineal part of the operation is now performed (p. 462), the mobilized portion of the bowel being drawn out of the pelvis after the coccyx has been removed.

The time required for both perineo-abdominal and abdomino-perineal operations can be materially shortened if the abdominal and the perineal stages are carried out simultaneously by two operating teams, the patient being in a high lithotomy position.

W. Q. W.

CHAPTER XXVIII

OPERATIONS FOR HERNIA

Inguinal: Anatomy. 'Radical Cure.' Irreducible. Sliding Strangulated. Femoral· Anatomy. 'Radical Cure.' 'Strangulated. Umbilical: 'Radical Cure.' Strangulated. Ventral: 'Radical Cure'.

OPERATIONS FOR INGUINAL HERNIA

Anatomy.—The inguinal canal extends from the deep inguinal ring, an oval aperture in the fascia transversalis situated 1·5 cm. (½ in.) above and slightly medial to the middle of the inguinal ligament, to the superficial inguinal rings a triangular aperture in the external oblique aponeurosis above and lateral to the pubic crest. In the adult the canal is about 4 cm. (1½ in.) in length and is directed medially with a slight inclination downwards and forwards. In the male it transmits the spermatic cord, in the female the round ligament of the uterus, and in both the terminal part of the ilio-inguinal nerve.

The anterior wall is formed by the external oblique aponeurosis, strengthened in the lateral third by the lower fibres of the internal oblique arising from the inguinal ligament. The posterior wall is formed by the fascia transversalis, together with the conjoint tendon at its medial part. The floor of the canal is formed by the inguinal ligament and its pectineal reflection to the body of the pubis The roof is formed by the arching fibres of the internal oblique and transversus muscles which span the contents obliquely. It is to be specially noted that the anterior wall is weakest at the superficial ring, the posterior wall at the deep ring.

The coverings of an oblique inguinal hernia, from without inwards, are the skin, the external spermatic fascia derived from the aponeurosis of the external oblique, the cremasteric fascia and cremaster muscle continuous with the internal oblique, the internal spermatic fascia representing the fascia transversalis, the extraperitoneal tissue and the peritoneum which constitutes the sac.

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In the case of larger and recurrent hernias and those where the abdominal musculature has lost its tone, it is now generally recognized that they constitute a separate problem requiring in addition to the removal of the sac a plastic operation appropriate to the particular case, designed to reinforce the posterior wall of the inguinal canal.

Operation in Children and Young Adults.—An incision is made about a finger's breadth above and parallel to the medial half of the inguinal ligament, exposing the aponeurosis of the external oblique. The cutaneous vessels are secured with forceps and the margin of the superficial inguinal ring is defined. The coverings of the cord are divided and stripped downwards by gauze dissection and the cord is exposed. If the cord is then pulled up and teased out laterally, the sac can usually be identified by its greyish-yellow colour. Its lower crescentic border having been defined is caught with artery forceps, and by continuing the gauze dissection in an upward direction it is stripped from its surroundings, special care being taken not to injure the vas deferens, which is usually adherent to its posterior aspect. It is separated from its attachments in the inguinal canal until a pad of yellow extraperitoneal fat comes into view, which indicates the neck of the sac. The sac is then transfixed at its neck with a double catgut suture, securely tied off, and the excess cut away The stretched fascia transversalis of the dilated deep inguinal ring is brought together with two or three fine interrupted catgut or linen sutures.

The subcutaneous fat, which is usually of some thickness in children and contains the superficial fascia, is brought together with fine catgut and the wound closed without drainage.

The stitches are removed on the sixth or seventh day and the patient may be allowed up in from ten days to a fortnight.

The success of the operation depends entirely upon the complete removal of the sac and, therefore, upon the adequate exposure of its neck. In young adults it is necessary to lay open the canal by dividing the aponeurosis of the external oblique in order to be certain of free exposure at the deep ring, and for repair of the fascia transversalis.

In infants the operation may be performed in the out-patient department at any age from two months to two years. A short transverse incision in the line of the skin fold over the superficial ring gives sufficient exposure, and, owing to the mobility of its structure, it is never necessary to open the canal The cord is identified and picked up where it emerges from the superficial ring, and the slender opalescent sac is dissected with care from the adherent vas. Gentle traction on the cord will reveal the neck, where the sac is ligated and excess removed The skin is closed with a few interrupted sutures and a waterproof dressing is applied and left until the stitches are removed, after which no further dressing is required.

Operation in Older Adults.—When the hernia is of long standing and has attained a considerable size, notably in persons over forty in whom the abdominal muscles have begun to lose their tone, the muscles of the canal become weakened and its fascial layers

stretched. In order to minimize the risk of recurrence in these cases, it is necessary in addition to removal of the sac to reinforce the posterior wall of the canal, but to interfere as little as possible with the function of its musculature.

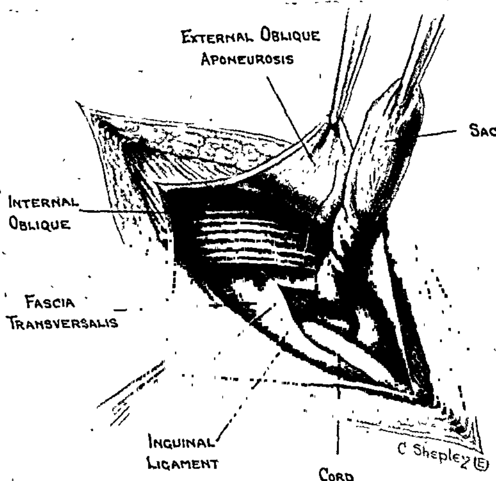


Fig 207. Operation for Inguinal Hernia

An incision is made parallel to the medial half of the inguinal ligament obliquely intersecting the line of the inguinal canal The superficial epigastric and pudendal vessels are ligated, and the superficial fascia is divided to expose the shining aponeurosis of the external oblique which is cleared by gauze dissection The canal is opened by slitting the aponeurosis in the line of the canal and holding aside its edges with forceps. The arching fibres of the internal

oblique arising from the inguinal ligament are exposed, and the inguinal ligament is cleared by gauze dissection until the lowest part of the shelving edge is defined. The spermatic cord is seen emerging under the lower edge of the internal oblique, covered by the cremasteric fascia derived from the lower border of the muscle. The lower edge of the internal oblique is then cleared so that it can be retracted upwards and laterally. At this stage the ilio-inguinal nerve is seen and preserved The cremasteric coverings are divided in the line of the cord, the cord is picked up, and the internal spermatic fascia derived from the fascia transversalis divided longitudinally. As a rule the sac is easily recognized on spreading out the structures of the cord, especially at the fundus where it presents a crescentic edge. In cases of difficulty it should be remembered that the spermatic plexus and vas are in close and direct relation to the sac, and that the vas can readily be palpated because of its hard, cord-like consistence

Mainly by gauze dissection, aided by touches of the knife, the sac is cleared up to the deep ring, which is recognized by the appearance of a yellow pad of fat The sac is opened to ensure that it is empty, the neck is transfixed and securely ligated, and the excess cut off, at this stage the stump recedes under the internal oblique muscle.

Until recently the method most commonly used to reinforce the inguinal canal was that of Bassini (Fig. 208). This aimed at strengthening the whole length of the posterior wall of the canal by stitching the internal oblique muscle and conjoint tendon to the inguinal ligament, behind the spermatic cord. Many surgeons regard this procedure as unsound, because it produces deformity of the inguinal canal with only temporary union of the conjoint tendon to the inguinal ligament. Its principles of adequate exposure and repair of the posterior wall remain valid, and are the basis of many other methods In the female the canal can be completely closed after removal of the sac, as it does not transmit any structure In the elderly with weakened tissue and in large or recurrent hernias it may be justifiable to sacrifice the testis to obtain a complete closure

In the Bassini operation the cord is lifted out of the canal and the lower edge of the internal oblique and conjoint tendon is united to the deep shelving edge of the inguinal ligament behind it by a series of interrupted sutures, the repair being carried well up to the deep inguinal ring so that the new posterior wall of the canal fits closely to the emerging cord The cord is then replaced on its new bed, and

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by stitching the upper leaf of the external oblique aponeurosis down

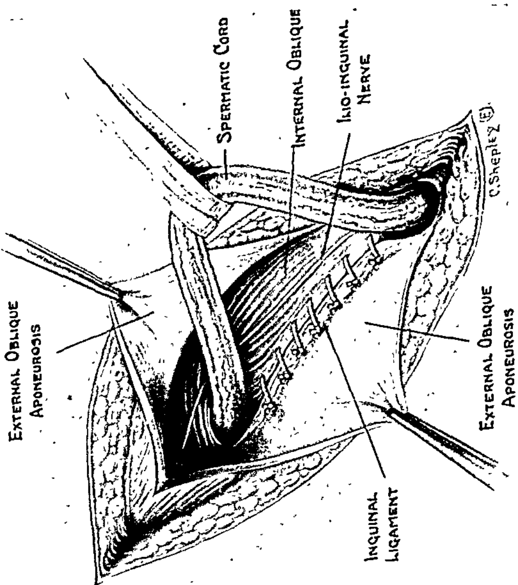


Fig. 208 Operation for Cure of Inguinal Hernia. Closure of Canal by Bassini's Method.

to the deep aspect of the inguinal ligament, behind the cord and on the surface of the conjoint tendon. The cord is then replaced and the lower leaf of the aponeurosis laid over it and united to the outer surface of the upper leaf, above the cord.

Fascial repair (Gallie and le Mesurier) utilizes strips from the fascia lata of the thigh These may be obtained, 0·5 cm., (¼ in.) wide, by using a fasciatome subcutaneously; or through a long incision on the lateral aspect of the prepared thigh, when it is often convenient to remove a strip 1·5 cm. (½ in.) wide and split it almost to one end to provide one strip of generous length. The gap in the fascia lata is closed by suture. The fascial strips are threaded on special wide-eyed needles and used to darn the gap or weak area, usually in two layers. They are applied without tension; any attempt to force the edges of the gap together would impair the success of the graft. When used to repair an oblique or direct inguinal hernia, the sutures grasp the edge of the internal oblique and conjoint tendon above and the deep aspect of the inguinal ligament below. They begin at the pubic crest, to which they are anchored, and extend laterally to the deep ring, where they are locked and made to encircle it. A second layer is superimposed through the internal oblique and conjoint tendon at a higher level, and through the inguinal ligament, to form a lattice and ultimately a permanent living graft. Alternatively, fascia may be obtained locally, though in less adequate length, as a strip from the external oblique aponeurosis.

Operation for Large Irreducible Hernia.—These operations are generally of considerable severity, as the patient is usually advanced in years, and operation is necessary for threatened strangulation The abdominal wall and the coverings of the hernia are laid freely open so that there is ample exposure of the parts in the region of the neck of the sac Adherent omentum is separated from the inside of the sac and the margins of the abdominal inguinal ring, care being taken that all vessels are secured before it is returned to the abdomen It is sometimes advisable to remove part of the omentum.

Operation for Sliding Hernia.—The operative treatment of the 'sliding' type of hernia presents special difficulties, as only the anterior and lateral aspects of the protruded bowel—caecum or pelvic colon—are covered with peritoneum, and the sac is incomplete. The ovary or the Fallopian tube may be contained in the hernia.

In the slighter degrees the peritoneum of the open sac is divided in a U-shaped fashion around the protruded viscus. The viscus is then freed extraperitoneally up to a point just above the neck of the sac. The raw surface on the posterior aspect of the viscus may be

peritonized with the attached fringes of sac wall, after which the viscus is returned to the abdomen. The defect in the sac is then closed by suture and the reconstituted sac is treated in the ordinary way.

Larger sliding hernias are best treated by a *combined inguinal and abdominal operation*. The whole sac may then be passed back into the abdomen and the canal repaired.

Operation for Direct Inguinal Hernia.—The direct type of hernia enters the canal through the inguinal triangle medial to the inferior epigastric artery, the fibres of the conjoint tendon being separated by the neck of the sac, which is usually wider than the fundus.

The operation is on the same lines as that for the oblique variety and requires an appropriate reinforcement of the posterior inguinal wall. Care must be taken to avoid injury to the bladder, which lies in the extraperitoneal fat on the medial aspect of the sac.

Strangulated Inguinal Hernia.—An incision is made a finger's breadth above and parallel to the medial half of the inguinal ligament, and the external oblique is slit up to open the canal. The coverings of the cord are usually so oedematous that they can readily be stripped from the sac by gauze dissection. When exposed the sac is of a dark blue or even black colour. Although tense, a fold of its wall can usually be picked up between the finger and thumb, or by forceps, on opening this by carefully cutting through the fold, a quantity of dark blood-stained exudate escapes, and the strangulated contents of the hernia are exposed. These may consist of a piece of omentum, of a loop of bowel, or of both. If the fluid which escapes is turbid and foul-smelling, it is probable that the vitality of the bowel is seriously impaired, and at this stage the sac and its contents should be irrigated with hot saline solution to minimize the risk of infection

The constricting agent, which is usually either the neck of the sac or the apex of the subcutaneous ring, is then divided, either by dissecting down upon it, or by slipping a hernia director under it, passing a probe-pointed knife along the groove in the director and cutting from within outwards. The contents are then gently pulled out until they are quite free of the constricting agent.

If omentum first presents it should be carefully teased out lest a small knuckle of bowel is embedded in it. The omentum is then clamped with forceps, cut off, and secured with catgut ligatures. The next step is to test the viability of the bowel. The constriction rings at both ends of the strangulated loop are first examined, and then the part between. If the colour of the bowel improves after it has been freed, if it contracts on being irrigated with hot

saline, and if it retains its gloss, it may safely be returned to the abdomen.

The operation is completed by obliterating the neck of the sac and closing the canal (p. 471).

If the bowel is not deemed to be viable, the affected segment is resected and lateral or end-to-end anastomosis performed (p. 418).

Operations for Femoral Hernia

Anatomy.—The femoral ring, or upper end of the femoral canal, is represented on the abdominal aspect by a slight depression, and it is closed by the femoral septum, a condensed portion of extraperitoneal tissue which contains a lymph gland. The ring is bounded in front by the inguinal ligament, behind by the pubic bone covered by the pectineus muscle and fascia, to the lateral side by the partition of the femoral sheath which separates ring from vein, and to the medial side by the pectineal part of the inguinal ligament (lacunar ligament). In its course from the external iliac the interior epigastric artery passes close to the upper and lateral angle of the femoral ring, and gives off a pubic branch which runs medially to the lacunar ligament to anastomose with the pubic branch of the obturator. An enlargement of this anastomosis constitutes an 'abnormal obturator', the obturator arising by a common trunk with the epigastric, when it curves round the medial side of the ring along the free margin of the lacunar ligament it is said to be liable to be wounded during herniotomy The femoral canal is 1 cm in length. In front of it the upper or falciform margin of the saphenous opening arches medially to join the inguinal and lacunar ligaments Behind it the upper part of the pectineal fascia is strengthened by a tough band of fibrous tissue known as Cooper's ligament. The coverings of a femoral hernia are the skin, the cribriform fascia, the femoral sheath representing the fascia transversalis, the extraperitoneal tissue and femoral septum, and the peritoneum which constitutes the sac.

Herniotomy for Femoral Hernia.—'*The Operation for Radical Cure.*'—The anatomical arrangement at the femoral ring renders its closure difficult and uncertain. The rigidity of the three sides of the ring formed by the inguinal ligament, the pectineal portion (lacunar ligament), and the horizontal ramus of the pubis reduces the chances of efficient closure, and the presence of the femoral vein on the lateral side limits the number of sutures.

The essential steps in the operation are. first, the obliteration of the neck of the sac at its highest point, and, secondly, occlusion of the femoral ring. Formerly there were two methods of approach: one above the inguinal ligament (Annandale and Lotheissen), the other below the inguinal ligament in the femoral triangle. For the last twenty-five years the operation has been standardized as a combined exposure permitting satisfactory dissection of the femoral sac from its coverings below, complete obliteration at the neck of the sac above, and repair of the femoral ring.

A horizontal or oblique incision is made as described for inguinal hernia, dividing skin and fascia, the lower edge of the wound is

drawn down and the hernia is exposed. The remaining bulky coverings are divided and the small, white, glistening sac is completely freed to its neck. It is opened at the fundus for inspection and its contents are reduced. The upper edge of the skin incision is

pillars of the superficial inguinal ring. The flaps are reflected, the

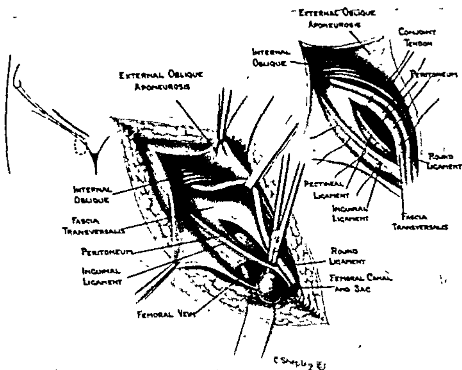


Fig. 209 Operation for Cure of Femoral Hernia.

round ligament or cord is retracted upwards, and the posterior wall of the inguinal canal, consisting of conjoint tendon and fascia transversalis, is divided in the line of and just above the medial end of the inguinal ligament. A curved forceps (cholecystectomy forceps) is now passed down the femoral canal, the empty isolated sac is clamped at its neck, the excess is removed and the stump is drawn up into the inguinal canal where it is transfixed and ligated, care being taken to avoid the bladder.

The femoral ring is now closed by suturing the conjoint tendon, *fascia transversalis, and inguinal ligament to Cooper's ligament*, thus extending the attachment of the inguinal ligament laterally towards the femoral vein, and as far as possible closing the femoral ring. During the insertion of these four or five interrupted sutures the

external iliac vein is protected by the first finger of the left hand. The operation is completed by suturing the divided external oblique aponeurosis and closing the deep fascia and skin in layers.

High obliteration of the neck of the sac is seldom followed by recurrence of the hernia, and many surgeons believe that any attempt to close the canal is valueless.

Operation for Strangulated Femoral Hernia.—The exposure is that employed for radical cure, and the operation is on similar general lines as that for strangulated inguinal hernia (p. 473). The neck of the sac having been exposed above the inguinal ligament and the rest of the sac isolated below the inguinal ligament, a flat director is passed between the neck of the sac and the constricting fascia and lacunar ligament. These are divided under direct vision, care being taken to avoid an abnormal obturator artery if it is present. The sac is opened at the fundus and the bowel inspected; if viable it is returned to the abdomen, if non-viable it is resected. The loop may be transferred above the inguinal ligament for resection and anastomosis, or it may be resected below, the remaining ends being closed and transferred above the ligament for the anastomosis (see also Chapter xxv). If there is extreme difficulty in obtaining adequate exposure the inguinal ligament may be divided; it is repaired when the anastomosis has been completed.

Great care must be taken that the bowel is not allowed to slip back into the abdomen before its viability has been determined. In grave cases the abdomen may be opened through a lower paramedian incision and the bowel transferred thence for resection.

Operations for Umbilical Hernia

Operations for Umbilical Hernia in Children.—In the great majority of cases of umbilical or para-umbilical hernia, so common during infancy, the opening closes under conservative treatment. If the hernia persists to the age of eighteen months however, the tendency to natural cure appears to cease and operative treatment is advisable.

Elaborate methods of closure are neither necessary nor advisable. A curved incision is made so as to reflect and preserve the umbilical scar, the sac is opened and the neck closed by ligature or suture. The edges of the opening in the linea alba are defined and brought together from side to side by a series of interrupted linen sutures. The skin-flap is now sutured back in place.

Exomphalos, or hernia into the umbilical cord of the newly born, may, if unaccompanied by other gross malformations, be operated upon during the first twelve hours of life.

Local anaesthesia by infiltration of the sheaths of the two recti

is the method of choice, though in large hernias the difficulty of reducing the contents of a large sac into a small abdomen may require the administration of a little ether.

The thin sac, formed by the stretched wall of the umbilical cord, is opened and trimmed off at its junction with the umbilical ring. The

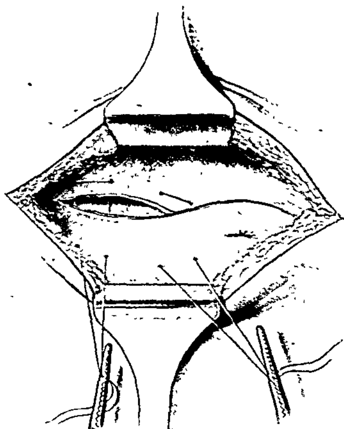


FIG. 210. Operation for Umbilical Hernia, by Mayo's Method.
(Sutures introduced to overlap edges of aponeurosis.)

ring is enlarged in an upward direction to facilitate reduction of the contents; it is important that the incision should be upwards rather than downwards, because at this early age the apex of the bladder tailing off into the urachus is commonly almost in contact with the lower margin of the ring.

After reduction of the hernia, strong through-and-through silk-[illegible]

O[illegible]

[illegible] usually very stout women, with irreducible omentum forming the main content of the sac. Two transverse

incisions are made outlining the hernial protrusion, and these are deepened through the fat, which may be several inches in thickness, until the aponeurosis is exposed for several inches above and below the sac. The sac is then defined and opened, not over the summit where the coverings are thin and adhesions are most likely to be present, but nearer the base of the protrusion. The intestine is

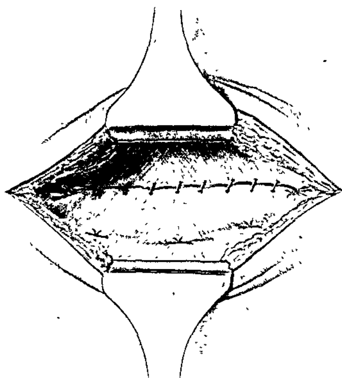


FIG. 211. Operation for Umbilical Hernia by Mayo's Method, completed.

returned to the abdomen, adherent omentum is dealt with on the usual lines, and the entire sac and overlying skin are cut away. The operation is completed by making the lower edge of the opening overlap the upper as follows (Figs 210–11): a stout, curved needle threaded with chromicized catgut, braided silk, or nylon is passed from without in through the aponeurotic structures and peritoneum from 5 to 8 cm. (2 to 3 in) below the margin of the opening, then as a mattress stitch through the lower edge of the upper flap, about 0·5 cm ($\frac{1}{4}$ in) from the margin, and finally through the hernial opening into the peritoneal cavity to emerge 0·8 cm. ($\frac{1}{3}$ in.) lateral to the point of original entrance. On each side of the first stitch is introduced a similar suture of strong chromicized catgut. The three

sutures are drawn tight, pulling the entire thickness of the aponeurotic and peritoneal layers behind the lower flap. The margin of the lower flap is retracted to expose the suture line, and if any gap exists it is closed with catgut sutures. The lower flap is now sutured to the surface of the aponeurosis above by a continuous suture, and, lastly, the skin and fat are brought together (W. J. Mayo). In small hernias the peritoneum may be closed as a separate layer before overlapping the aponeurosis. A drainage tube should be inserted through a separate opening to prevent subcutaneous haematoma. The patient is kept in bed for three weeks, and before getting up is provided with an abdominal belt or corset; the muscles are re-educated by breathing and other exercises.

Operation for Strangulated Umbilical Hernia.—In operating for strangulated umbilical hernia it is to be borne in mind that the sac is often loculated, and separate coils of intestine as well as portions of omentum may occupy the different loculi. After the sac has been exposed and opened as described above, each loculus must be separately explored, adherent omentum separated, and any coil of intestine that may be implicated examined for evidence of strangulation. The omentum and bowel are dealt with on the usual lines, and after they have been returned to the abdomen the opening is closed after the method of Mayo.

Operations for Ventral Hernia

The commonest cause of ventral hernia is the stretching of a cicatrix resulting from a previous operation, and the operation for its cure consists in reconstituting the abdominal wall as accurately as possible by stitching together its different layers. The details of the operation vary, therefore, with the situation of the hernia.

When the original operation has been performed in the middle line, particularly below the umbilicus, the hernia bulges between the two rectus muscles, stretching and thinning out the linea alba. A similar condition frequently develops in multiparous women who have had no operation—*divarication of the recti*. An incision—vertical or horizontal according to the size and disposition of the protrusion—is made, the thinned-out linea alba, together with the sac, excised, the peritoneal edges, the margins of the recti, and the rectus sheaths are stitched in separate layers with chromicized gut, and the skin wound closed with silk [illegible]

the [illegible]

region are reconstructed.

Large ventral hernias may be treated by darning the gap with a fascial suture, or by inserting a flat graft of fascia from the thigh.

The deeper layers of skin also provide a suitable sheet of fibrous tissue, which when used as a free autograft (E Rehn) can be sutured over the defect, it is best to remove the epidermis with a razor before cutting from the skin of the thigh the dermis to be transplanted.

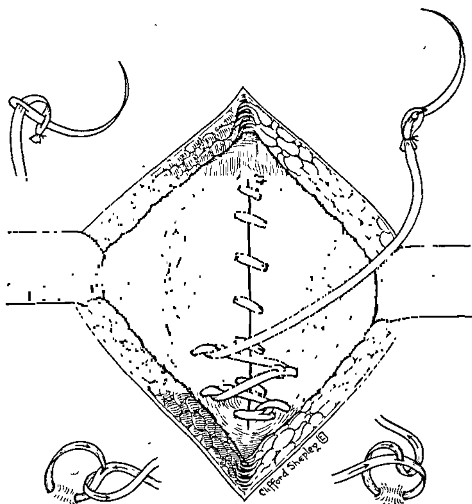


FIG 212 Closure of Ventral Hernia by darning with Fascial Suture.

An alternative method is to separate both rectus muscles from their origins, and transpose these to overlap the muscles (Nuttall).

Epigastric hernia occurs in or near the middle line above the umbilicus It consists of a pad of extraperitoneal fat which has worked its way through the linea alba, dragging a process of peritoneum after it. The sac, having been defined, is transfixed at its neck by a double catgut suture, tied securely, and cut off. The opening in the linea alba is then closed.

J. R. J. C.

CHAPTER XXIX

OPERATIONS ON THE SPLEEN

Anatomy. Splenectomy.

The Spleen

Anatomy.—The concave, medial surface of the spleen lies against the fundus

by peritoneum, and from the hilum the peritoneum is reflected on to the fundus of the stomach as the gastro-splenic omentum; a similar fold—the lieno-renal ligament—passes backwards to the anterior surface of the left kidney. The splenic vessels pursue a tortuous course behind the lesser sac, the artery being uppermost. Near its termination the artery breaks up into from five to seven branches, which enter the organ separately.

Splenectomy.—This operation is indicated (1) in rupture of a normal or pathologically enlarged spleen, (2) in certain cases of haemolytic jaundice, (3) in certain cases of thrombocytopenic purpura, and (4) in such rare conditions as Gaucher's disease, primary tumours of the spleen, torsion of the pedicle of a 'wandering' spleen, aneurysm of the splenic artery, Egyptian splenomegaly, abscess, and tuberculosis.

Splenectomy is of benefit only in the *primary* group of haemolytic anaemias. In the *congenital* type operation should be advised in an interval between haemolytic crises; if the disease manifests itself in early life, operation may reasonably be deferred till the age of 10–12 years. In the *acquired* (primary) type splenectomy is to be regarded as the last resort, the result of operation is unpredictable, and it should be preceded by transfusion, repeated if necessary. In *acute thrombocytopenic purpura* in children spontaneous recovery, with or without transfusion as may be indicated, can be expected in the majority of cases. Spontaneous recovery is less common in adults, but the decision to perform splenectomy is one for the joint determination of haematologist and surgeon. In *chronic thrombocytopenic purpura* spontaneous recovery is rare, and operation may be more confidently recommended, especially if the haemorrhagic tendency continues to impair the health of the patient.

A general anaesthetic is given through an intratracheal tube, an air-cushion is placed behind the lower ribs, and a stomach-tube inserted to ensure that the stomach is empty of gas. The abdomen is opened through a long left paramedian incision.

The first step is to gain access to the pedicle. This is attained by dividing the lower half of the gastro-splenic omentum between

The deeper layers of skin also provide a suitable sheet of fibrous tissue, which when used as a free autograft (E. Rehn) can be sutured over the defect; it is best to remove the epidermis with a razor before cutting from the skin of the thigh the dermis to be transplanted.

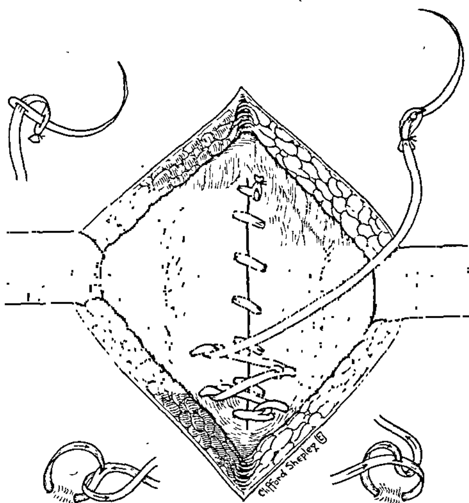


Fig. 212 Closure of Ventral Hernia by darning with Fascial Suture

An alternative method is to separate both rectus muscles from their origins, and transpose these to overlap the muscles (Nuttall).

Epigastric hernia occurs in or near the middle line above the umbilicus It consists of a pad of extraperitoneal fat which has worked its way through the linea alba, dragging a process of peritoneum after it. The sac, having been defined, is transfixed at its neck by a double catgut suture, tied securely, and cut off. The opening in the linea alba is then closed.

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ligatures (Fig. 213); by compressing the vessels between the fingers and thumb of the left hand any bleeding during the operation is quickly controlled. The second step is mobilization of the spleen, which is held in position by the lieno-renal ligament. The spleen is gently drawn to the right, the left costal margin is retracted, and with a long-handled knife or long scissors the outer leaf of the lieno-renal ligament is divided (Fig. 214). This allows the spleen to be

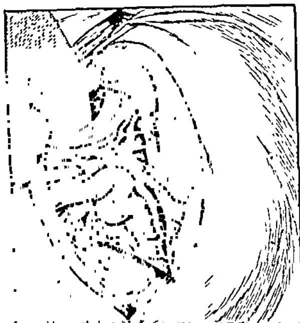


Fig 215 Splenectomy. Splenic Artery has been ligated in two places Ligature being passed round Splenic Vein.

drawn forwards and to the right, and by dividing the subperitoneal cellular tissue or fascia propria a further mobilization is secured. The organ can now be brought up into the wound, when the upper half of the gastro-splenic omentum containing the vasa brevia is divided between ligatures, care being taken not to injure the stomach or include it in a ligature where it comes into direct contact with the upper pole of the spleen The lower pole of the spleen is freed from the colon and the organ is now attached solely by its true vascular pedicle A large hot pack is passed into the splenic bed to raise the spleen and to check oozing. The forefinger of the left hand is passed behind the pedicle and the splenic artery, which lies at the upper border, is isolated and ligated in three places (Fig. 215). The tail of the pancreas is dissected off the splenic vein, which is also ligated in three places. By cutting between the middle and distal ligatures the spleen is completely detached To avoid injury to the veins, which

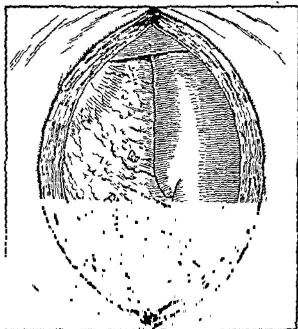


FIG. 213 Splenectomy. Ligation of Vessels in Gastro-splenic Omentum

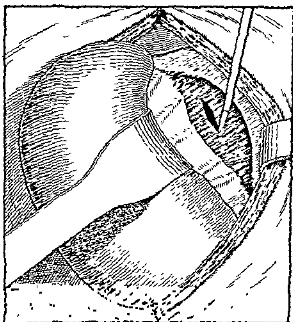


FIG. 214 Splenectomy Mobilization of Spleen by division of Peritoneum and Fascia of Lieno-renal Ligament.

CHAPTER XXX

OPERATIONS ON THE KIDNEY AND URETER

Anatomy. Lumbar Nephrotomy. Nephropexy. Nephro-lithotomy. Nephrectomy. Nephrostomy. Decapsulation of Kidney. Operations on the Ureter. Ureteral Anastomosis.

to the last thoracic and upper three lumbar vertebrae, the psoas muscle intervening between the kidney and the transverse processes. The kidneys are placed obliquely, so that one surface looks forwards and laterally, while the other looks backwards and medially. The left kidney usually reaches slightly higher than the right, its upper border being on the level of the upper margin of the seventh costal cartilage, while that of the right kidney reaches only to the lower margin of the same cartilage. As viewed from the front, the greater part of each kidney lies to the medial side of a line drawn vertically upwards from the centre of the inguinal ligament.

The kidney is invested by a *fibrous* or *true capsule* which is readily detached from its surface Outside this is the perirenal fat, which forms a second investment for the kidney—the *adipose capsule*. This fat, which is most abundant on the posterior and lateral aspects of the kidney, is enclosed by the *perirenal fascia*, the anterior layer of which is intimately blended with the parietal peritoneum, while the posterior layer is in contact with the lumbar fascia. Above the kidney the perirenal fascia forms a separate fibrous compartment for the suprarenal gland, which explains why this organ does not accompany the kidney when it is displaced Below the kidney the two layers of the peri-

descending part of the duodenum, and the hepatic flexure of the colon The left kidney is related in front to the suprarenal gland, the stomach, pancreas, and spleen, and to the splenic flexure of the colon and the upper coils of small intestine

The pelvis of the kidney lies opposite the transverse processes of the first and second lumbar vertebrae.

The *ureter* lies on the psoas muscle, and is closely adherent to the parietal peritoneum. It descends almost vertically about 3 5 cm. (1½ in.) from the mesial plane, and dips into the pelvis in front of the termination of the common iliac artery, two fingers' breadth above a point where a line joining the anterior superior iliac spines cuts a vertical line from the spine of the pubis. The renal blood-vessels enter at the hilum, the vein lying in front of the artery. The ureter lies behind the vessels The lymphatics pass from the hilum to the retroperitoneal glands

The blood-vessels are distributed in the kidney substance in two main groups, an anterior and a posterior, and the cortex may be cut through to gain access to the pelvis with the minimum loss of blood if the incision is made slightly to the dorsal side of the convex border of the organ The ureter is so well supplied with blood-vessels running in its wall that it may be lifted from its bed to a considerable extent without its vitality being impaired.

may be very friable, stout catgut should be used. After removal of the pack, any bleeding-points are underrun with a catgut stitch.

If the operation is being performed for haemolytic anaemia or for purpura, the abdomen must be searched for accessory spleens, the presence of which may perpetuate the primary disease. In order of frequency the likely sites are (1) the neighbourhood of the hilum, (2) the pedicle, (3) the retroperitoneal tissues near the pedicle, (4) the omentum, (5) the mesenteries of the large and small intestines, and (6) in women, the left ovary and tube.

In haemolytic anaemia, a search of the gall-bladder and bile-ducts for pigment stones is an essential stage of the operation; if present, they must be removed (p. 395).

When the spleen is enlarged, its content of blood may be restored to the circulation, after ligation of the splenic artery and before ligation of the splenic veins, either by faradizing the pedicle distal to the most distal ligature, or by injecting intramuscularly 10–20 minims of a 1 in 1,000 solution of adrenalin hydrochloride.

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and is carried forwards and downwards towards the anterior superior iliac spine, as far as the anterior axillary line (Fig. 141 b). The exact length of the incision depends on the individual case—the type of operation contemplated, the degree of adiposity, and

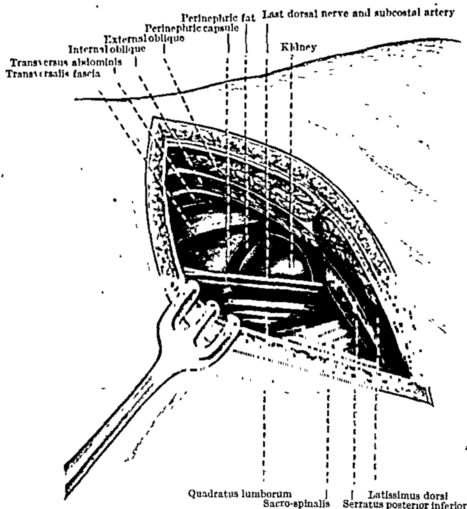


FIG. 217 Exposure of Left Kidney by Lumbar Incision.

the breadth of the space between the last rib and the iliac crest. It may require to be prolonged above and parallel with the iliac crest and inguinal ligament as far as the abdominal inguinal ring.

After division of the skin and subcutaneous fat the incision divides posteriorly the latissimus dorsi and the underlying lumbo-dorsal fascia, the thin serratus posterior inferior may be seen. Anteriorly the external oblique, internal oblique, and transversus muscles are divided and the transversalis fascia and underlying

The main sympathetic nerve-supply to the kidney comes from the renal plexus, which receives branches from the splanchnics through the semilunar ganglion. Most of the fibres, both efferent and afferent, lie in relation to the adventitia of the renal artery and can therefore be interrupted by a periarterial sympathectomy. Division leads to vasodilatation and diuresis, relaxation of the pelvi-ureteral sphincter muscle, and renal anaesthesia. It is probable that the renal capsule also contains vasoconstrictor and afferent fibres.

Operations on the Kidney

The chief indications for exposing the kidney are: rupture with dangerous haemorrhage, hypermobility of the kidney, renal calculus,

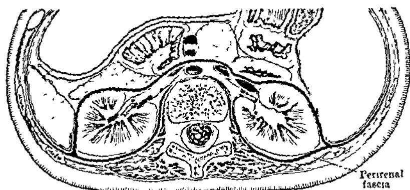


Fig. 216. Transverse Section of Abdomen, Showing Position of Kidneys.

hydronephrosis or pyonephrosis, tuberculosis, tumours, and certain cases of acute pyelonephritis and of nephritis

Except in simple drainage operations, free exposure and mobilization of the kidney through a relatively long parietal incision are essential in order to ensure exactitude in diagnosis, freedom to modify the technique as required, and immediate control of haemorrhage. Satisfactory exposure is obtained in the great majority of cases through an oblique lumbar incision designed to approach the kidney *extraperitoneally*. In exceptional cases, for example when dealing with a very large tumour or when the space between the rib margin and iliac crest is greatly reduced by the presence of a spinal curvature, a transperitoneal exposure may be practised

Operation to Expose the Kidney by the Lumbar Route (Fig. 217).—The patient is placed on his sound side, with an air pillow or cushioned bar inserted between the costal margin and iliac crest to open up the loin on the affected side The upper leg is straight, while the lower is flexed at the hip and knee The arm on the affected side is supported in order to prevent pressure on the thorax.

The incision is commenced posteriorly in the angle between the sacro-spinalis and the twelfth rib or over the centre of the latter,

the aid of dissecting forceps and a blunt dissector. The capsular incision is therefore I-shaped.

Strong chromicized catgut sutures are passed through the four corners of the separated capsule, single knots are tied, and the ends are left long. The kidney is then replaced with its raw surface pressed against the denuded muscles of the kidney bed. The ends of the four capsular sutures are carried through the musculo-aponeurotic tissues on each side, pulled taut, and tied. There are thus upper and lower anchorages anteriorly and posteriorly. A 'cigarette' drain is inserted to the lower pole of the kidney, and the parietal wound is closed in layers.

It has been recommended that the anchoring sutures, or a flap of capsule, should be passed round the last rib, but this is not free from the risk of injury to the pleura. Brödel recommended slinging up of the kidney by means of silkworm gut sutures threaded through the capsule at the lower pole of the kidney and brought out through the aponeuroses and skin.

Operations for Renal Calculus

Surgical treatment is necessary in most cases of renal lithiasis, the exact technique employed being influenced by the site, size, and number of the stones, the presence of obstructive hydronephrosis or sepsis, and the state of the opposite kidney. Such essential data can be obtained only from a thorough pre-operative investigation in each case

To avoid immediate post-operative complications and recurrence of stone formation, the surgeon aims at the removal of the calculi with the minimum of damage to the secreting tissue, the correction, if possible, of factors influencing stone formation, and the eradication of sepsis

Various operative procedures may be employed: (1) Nephro-lithotomy—incision of the renal substance and removal of the stone; (2) pyelo-lithotomy—incision of the renal pelvis and removal of the stone, (3) pyelo-nephro-lithotomy—a combination of the preceding two measures; (4) nephrectomy—excision of the kidney; (5) nephrostomy—simple drainage.

Nephro-lithotomy.—This operation is indicated when a stone is imprisoned in a calyx and is palpable from the surface. The kidney having been exposed and brought to the surface of the wound, a finger of one hand invaginates the pelvis while the exterior of the kidney is palpated with the fingers of the other hand When the stone is located it is fixed by the finger invaginating the pelvis, and a short incision is made along the convex border through the kidney substance until the stone is struck and can be removed. If

peritoneum are exposed. The peritoneum is freed forwards and the intermuscular vessels are secured. Posteriorly the perirenal fascia and the lateral margin of the quadratus lumborum are seen with the last thoracic nerve and the subcostal artery lying in relation to the latter. The ilio-hypogastric nerve lies under cover of the quadratus lumborum.

If further exposure is required posteriorly and above, the quadratus lumborum may be partially divided 2·5 cm. (1 in.) below the last rib and the external arcuate ligament incised, care being taken to avoid wounding the pleura. On this account the finger should be insinuated below the ligament before dividing it. Subperiosteal resection of the last rib, to obtain further access, should practically never be needed

Forceps are applied far back to the perirenal fascia and an opening made in it The kidney is then mobilized by blunt dissection through the fatty capsule and brought towards the surface. The dissection is facilitated if the assistant makes firm pressure through the anterior abdominal wall while the surgeon strips the fat from the kidney. This dissection may be easy, or it may be rendered tedious by the presence of adhesions In dividing such adhesions at the upper pole of the kidney care should be taken to ligate them before division, as they may contain aberrant vessels.

The renal pelvis and upper end of the ureter are now freed and the kidney is, if possible, delivered on to the surface, care being taken to avoid undue traction on the structures forming the vascular pedicle. The further procedure depends on the pathological condition present.

Nephropexy.—This operation, first successfully carried out by Hahn of Berlin in 1881, consists in anchoring an unduly movable kidney, and is indicated when the hypermobility *per se* is giving rise to definite symptoms, is interfering with drainage, and is thereby leading to damage to the kidney.

The usual dissection is made through the loin, employing the standard oblique incision, or access may be gained by a vertical incision lateral to the sacro-spinalis, which separates the fibres of the latissimus dorsi and splits the lumbo-dorsal fascia. Special care must be taken in dividing the perinephric fascia to avoid opening the peritoneal cavity, as the kidney, especially when of the floating type, virtually possesses a mesentery. The perinephric fascia is opened very far back. The kidney is projected towards the surface by pressure made by an assistant and is brought out of the wound after division of the many filmy adhesions passing from its capsule to the perinephric fascia. The capsule is then incised along the convex border of the kidney, and at each pole two transverse incisions are made so as to form two leaves when the capsule is stripped up with

are sufficiently wide should the calculi be extracted by means of forceps. If the neck of the calyx is narrow in relation to the size of the contained calculus, such a procedure is dangerous owing to the risk of haemorrhage from damage to the adjacent vessels as the calculus is being extracted. In such cases the tip of the finger in the pelvis is maintained in contact with the calculus, which is cut down upon and removed through a small incision in the renal cortex as described under nephro-lithotomy (Fig. 218). The incisions in the pelvis and cortex are both closed.

Excision.—Removal of the kidney in calculous disease is indicated when there is marked atrophy of the secreting tissue from backward pressure, or if there is severe or long-standing infection—pyelonephritis or pyonephrosis—and especially if the infection is staphylococcal in nature.

On account of extensive perirenal adhesions it may be necessary to carry out the operation by the subcapsular method (p. 492). In all cases the function of the opposite kidney must previously have been proved to be adequate.

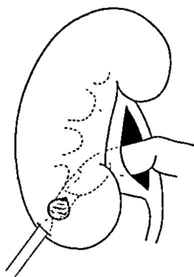


Fig 218. Pyelo-nephro-lithotomy. (After Swift Joly)

Nephrostomy.—This operation is employed as an emergency measure and, as such, is called for in cases of calculous anuria and in calculous pyonephrosis, especially when the opposite kidney is extensively diseased or has been destroyed by antecedent disease. The technique is described on p. 493.

Nephrectomy

Excision of the kidney is indicated for tumours, e.g. hypernephroma, unilateral renal tuberculosis; hydronephrosis or pyonephrosis when the renal substance is destroyed or is functionally useless, and in cases of severe injury. For the removal of the kidney access may be gained either from the loin or through an abdominal transperitoneal incision. The lumbar operation is preferred except in the case of very large tumours.

Lumbar Nephrectomy.—The kidney is exposed through the usual lumbar incision, which may be extended downwards and forwards as far as is necessary. The perirenal fascia is divided and the kidney is mobilized by separating the fatty capsule from it. If the

the exact site of the stone is uncertain, the insertion of a straight round-bodied needle through the cortex will localize it beyond doubt. Great care is taken to avoid making the incision so deep as to divide the neck of the calyx, such division being liable to occasion severe haemorrhage from the large blood-vessels which may be felt pulsating at this site After removal of the stone the cavity of the calyx is gently flushed out with warm saline, and the incision is closed with catgut sutures, which pick up the capsule and just sufficient of the tissue of the cortex to give a bite. A drain is inserted down to the kidney and the parietal wound is closed in layers.

When multiple stones of the same type are present in several calyces, multiple limited incisions of similar nature should be made for their removal through the renal cortex. The older nephrotomy operation in which the kidney was bisected is not recommended, as it is liable to be followed by such dangerous reactionary or secondary haemorrhage that nephrectomy may be necessitated to save the patient's life.

Pyelo-lithotomy.—This operation is not attended by the same risk of haemorrhage as nephro-lithotomy, and does not interfere with the secretory function of the kidney. The risk of subsequent leakage and the establishment of a urinary fistula is remote and has been greatly exaggerated The operation is indicated for all stones in the pelvis, and for those in the calyces which can be dislodged into the pelvis by virtue of their small size or the dilatation of the necks of the calyces secondary to backward pressure.

The kidney and pelvis are exposed, and the posterior wall of the latter is cleared of fat and packed off. The pelvis is opened by an incision radiating towards the pelvi-ureteral junction, directly over the stone, and catch forceps are applied to the edges of the incision. The incision may have to be prolonged proximally and a marginal vessel running in the sulcus between the kidney tissue and the pelvis secured before the incision is thus extended (Eisendrath). The stone is removed and the cavity explored by the finger to make sure that no fragments have been missed. The incision in the pelvis is closed with through-and-through sutures of fine plain catgut after verifying the patency of the uretero-pelvic junction with a bougie. A drain is inserted down to the peripelvic tissues and the parietal wound is closed

Pyelo-nephro-lithotomy.—This operation is frequently indicated when calculi are situated in the pelvis and the calyces, as it allows of satisfactory exploration of the whole cavity.

The initial technique is the same as in pyelo-lithotomy, but after the calculi have been removed from the pelvis the finger is introduced and the calyces are examined Only when the necks of the calyces

of the kidney. It is also used in rupture of the kidney when haemorrhage is taking place into the peritoneal cavity and when there is reason to suspect that other abdominal viscera have been injured.

The incision is made in or near the median line of the abdomen; a lateral incision, in the line of the intercostal nerves, may be added to it. Some prefer a single free incision below and parallel with the *last rib, the anterior portion of which is deepened to open the* peritoneal cavity. The rectus may require division in order to obtain sufficient access. The kidney is at once exposed with the ascending or descending colon in front of it, and the question of its removal decided upon. The small intestines are packed away to the other side of the abdomen, and the posterior parietal peritoneum is incised parallel with and along the lateral border of the colon, and the colon is stripped towards the median line. In tumour cases the kidney is shelled out with its fatty capsule by blunt dissection until the pedicle is reached. The pedicle is more easily dealt with by the transperitoneal than by the lumbar route. Difficulty may be met with in relation to extension of the growth along the renal vein, and adhesions to the surrounding parts, especially those beneath the vault of the diaphragm. On the left side, adhesion to the spleen may necessitate the sacrifice of part or the whole of this organ. The removal of a large renal tumour will sometimes necessitate the *removal of the adrenal* as well, but this will do no appreciable harm provided the other one is intact.

After the kidney has been removed, the raw surface is covered over by suturing the edges of the peritoneum. A drainage tube is brought out through an opening in the loin.

Nephrostomy: Pyelostomy.—In cases of hydro- or pyonephrosis in which it is possible to remove the obstruction to the escape of urine along the ureter, and in which a considerable portion of the secreting tissue of the kidney remains and is of functional value, a temporary opening may be made in the kidney or in the pelvis for purposes of drainage. It should be understood that, when the opposite kidney is healthy, such conservative operations are rarely justified, liability to recurrence of disease, especially infection, being pronounced. Further, a subsequent nephrectomy, if necessary, may be rendered difficult on account of the adhesions formed. The main indications for such operations are post-renal anuria due to calculous or inflammatory obstruction, and calculous pyonephrosis when the opposite kidney is already diseased and when drainage through an indwelling ureteral catheter is impracticable.

Under gas and oxygen anaesthesia the kidney is exposed through a lumbar incision, the perirenal tissues being disturbed as little as possible, to minimize the risks of infection. If the opening is to

kidney is being removed for malignant disease, the fatty capsule should, as far as possible, be removed with it. On the other hand, cases are met with in which the diseased kidney is so intimately fused with the surrounding structures by dense inflammatory adhesions that an attempt to remove it intact in its capsule would be both difficult and dangerous. In such cases an incision is made in the true capsule and through this the organ is enucleated—*subcapsular nephrectomy*.

After the kidney has been freed posteriorly, the ureter is isolated below, ligated in continuity, and, having been clamped immediately above the ligature, is divided across with the cautery or a knife previously dipped in strong carbolic. In suppurative and tuberculous conditions, the utmost care must be taken that the contents of the ureter do not infect the wound. When it is thickened and infected with tuberculous disease the ureter may require to be excised right down to its termination in the bladder.

The kidney and pelvis are now freed all round, special care being required, when operating on the right side, to avoid injury to the duodenum and to the inferior vena cava. The latter is specially liable to injury when a large hydronephrotic sac has insinuated itself posterior to the vein.

Finally, the renal pedicle is dealt with. If a long pedicle can be obtained, it is grasped between the fingers and thumb and the renal artery and vein are isolated, ligated separately with strong catgut, and divided. If the pedicle is too short to admit of this, the structures at the hilum must be ligated *en masse*. After they have been divided and the kidney removed, the artery and vein are secured separately, or a second mass ligature is applied. In dealing with malignant growths a solid mass of tumour tissue may be found projecting into the renal vein, and care must be taken to avoid expressing this as a malignant embolus into the vessel proximal to the site of ligature

When the subcapsular method is found to be necessary, the initial stages of the operation will be carried through with ease, but when the stage of ligating the vessels in the renal pedicle is reached more difficulty will be encountered To accomplish this step it is necessary to divide the capsule adjacent to the pedicle, isolate the vessels proximally, and ligate them in this situation

If there is a perinephric abscess, this should be emptied before enucleating the kidney, in pyonephrosis any specially large abscess cavity should also be emptied with a large trocar and cannula before proceeding with the removal of the organ

Transperitoneal Nephrectomy.—The transperitoneal route is occasionally selected for the removal of exceptionally large tumours

Very free exposure through a lumbar incision is essential for the success of the operation, and difficulties may be encountered from fibrotic adhesions or an abnormally short pedicle. The kidney and upper end of the ureter are completely freed and the renal pedicle is stripped laterally from near its mesial end. Great care is taken of the thin-walled renal vein as injury to this may necessitate immediate nephrectomy. Oldham recommends that subsequently the pedicle should be swabbed with 10 per cent. phenol, which will destroy small nerve filaments missed in the dissection, or will show up larger fibres that can then be divided.

Operations on the Ureter

Exposure of the Upper End of the Ureter.—The upper abdominal portion of the ureter is exposed by the same incision as is employed for exposure of the kidney. It is frequently necessary, especially in stout subjects, to prolong the incision downwards and forwards. The kidney, having been enucleated from its fatty capsule and brought out at the wound, is first drawn backwards to display the anterior surface of the ureter, and then towards the median line to give access to the posterior surface (Fig. 220) The further procedure depends on the condition for which the operation is undertaken. If there is a stone impacted in the ureter, the wall is incised in the longitudinal axis and the stone removed—*uretero-lithotomy*. A sound should be passed down the ureter to make sure that it is patent throughout, and that there is no stone farther down in its course. The wound in the ureter is closed with fine plain catgut sutures, and drainage of the main wound is provided for.

If the operation is performed for hydronephrosis due to kinking of the upper end of the ureter, the kink can usually be undone by fixing the kidney in position by nephropexy. If a severe valvular obstruction is found at the junction of the ureter with the pelvis, it may require correcting by a plastic operation, re-implanting the ureter, or making an anastomosis between the ureter and the most dependent part of the pelvis (Fig. 221). These operations for hydronephrosis are usefully combined with such procedures as removal of the excess tissue of the pelvic sac, and temporary nephrostomy (p. 494).

Although *wounds* of the ureter can usually be efficiently closed by sutures, it is advisable to provide for drainage of the external wound.

Operations on the Abdomino-pelvic Portion of the Ureter.—*Exposure of the iliac portion by the extraperitoneal route.*—The patient is placed on his back with the head of the table slightly lowered and a sand-bag inserted below the pelvis on the affected

be made through the kidney substance direct (*nephrostomy*) it is necessary to expose only the convex border, in which an incision is made large enough to admit the finger; the cavity is explored, washed out with saline, and calculi if present and accessible are removed. A tube is inserted into the cavity and the wound is closed. When the renal pelvis is distended and the kidney tissue is engorged and thickened, as in anuria associated with an obstruction in the ureter, the pelvis is exposed and incised. If a calculus is present and is readily accessible, it is removed and a tube is stitched into the pelvis (*pyelostomy*). A preferable method of obtaining drainage is to pass the finger-tip from the pelvis into the lower calyx and cut down upon it through the renal substance. A mushroom-ended, self-retaining catheter with its tip cut off is then guided into the calyx and anchored by a catgut stitch to the renal capsule The wound in the pelvis is closed with catgut sutures and the parietal wound is drained (Fig. 219).

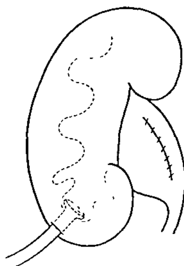


FIG 219. Nephrostomy.

When it is desired to make a permanent opening for drainage, the ureter is brought out in the loin—*ureterostomy*.

Decapsulation of the Kidney.—Although this procedure has not proved beneficial in chronic Bright's disease, for which it was originally suggested by Edebohls, it has been followed by marked improvement in certain cases of parenchymatous nephritis Combined with incision of the kidney substance it has also proved helpful in cases of diffuse suppurative nephritis. Decapsulation has also been employed with some measure of success in cases of essential haematuria and of nephralgia.

The kidney, having been exposed by the lumbar route, is readily shelled out from the oedematous perirenal tissue; an incision is made through the capsule, which is stripped from the surface and cut away with scissors. The kidney is then replaced in its bed and the wound closed.

Renal Denervation.—This operation was first practised by Papin in 1921 and has been recommended for the treatment of small painful hydronephroses, for nephralgia of unexplained origin, and, occasionally, for essential haematuria In all those conditions an error in the sympathetic nerve supply has been claimed as the causative factor.

isolated, especially if it is thickened by disease or is the seat of an impacted stone. The further manipulations are made easier if a loop of tape is thrown round the ureter and clamped with artery forceps to act as a retractor. When found, the ureter can be traced on the posterior abdominal wall towards the kidney, and downwards beyond the bifurcation of the common iliac artery along the wall of the true pelvis. If a stone is impacted in the pelvic portion, it should, if

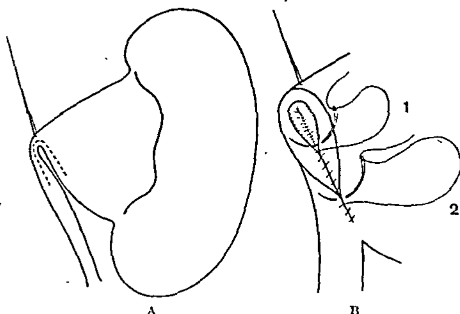


Fig. 221. Pyelo-ureterostomy.

A. Dotted line indicates incision in pelvis and ureter.
B 1 Posterior line of suture nearly completed.
2 Commencement of anterior line of suture.

possible, be displaced upwards to a more accessible part to facilitate the stitching of the wound in the ureter. The incision in the ureter should be in the longitudinal axis, and subsequent drainage of the main wound is required.

Exposure of the lowest 10 cm of the Ureter.—For this purpose the extraperitoneal method should again be employed. Access may be gained through an oblique incision as described above, more room being obtained, if necessary, by prolonging the incision medially and by partly dividing the rectus sheath and retracting the rectus muscle medially. With the patient in the Trendelenburg position access may be gained by a median hypogastric incision. The bladder is exposed and retracted, and the peritoneum is stripped from it and from the side wall of the pelvis. Care must be taken in the female to avoid injury to the uterine vessels.

side. An incision is made in the line of the fibres of the external oblique muscle with its centre 3·5 cm. (1½ in) medial to the anterior superior spine of the ilium. The external oblique muscle and aponeurosis are split in the line of the fibres, and the internal oblique

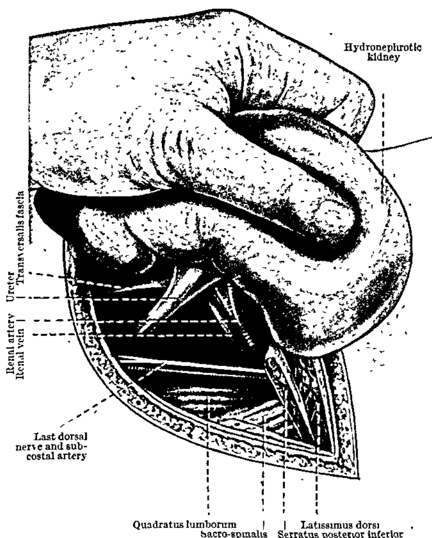


Fig 220 Exposure of Upper Part of Left Ureter.

and transversus muscles are split in the line of their fibres, as in McBurney's appendix approach, or preferably, to give freer access, they are divided in the same line as the external oblique Branches of the deep circumflex iliac artery require ligation The transversalis fascia is divided and the peritoneum is carefully stripped up from the fascia over the iliacus and psoas muscles The ureter is lifted off the great vessels along with the peritoneum, it is easily recognized and

united by the invagination method introduced by van Hook. As usually performed, the vesical end of the ureter is closed, and lower down a longitudinal slit is made, into which the renal end of the ureter is inserted. The edges of the slit are then stitched all round to the wall of the portion implanted in it with fine sutures. This procedure may be carried out either trans- or extraperitoneally.

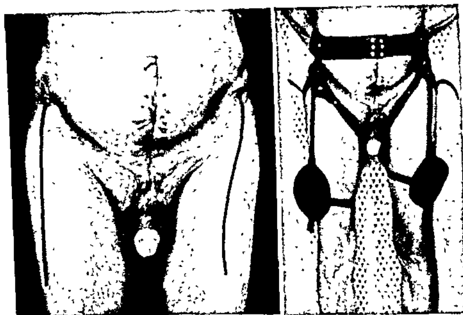


Fig. 222. Ureterostomy.

A. Artificial urinary fistulae with tubes inserted.
B. Apparatus for collection of urine

An alternative method consists in carrying out an end-to-end anastomosis of the ureter over a ureteral catheter which has been passed up from the bladder. The catheter may be left in for a few days.

Implantation of the Divided Ureter into the Bladder.—In resections of the bladder for cancer it is sometimes necessary to sacrifice the lower portion of one or other ureter. The upper end must then be re-implanted through a fresh opening into the bladder—*uretero-cysto-neostomy.*

The simplest method available should be used, as it is impossible to provide an artificial uretero-vesical sphincter. The ureter is cut across and, by means of a silk suture, is pulled through a small opening made in the bladder wall, so that it projects 0·5 cm. (¼ in.) beyond the mucous membrane of the bladder. A row of interrupted catgut sutures is then inserted to unite the outer coat of the ureter

A transperitoneal exposure of the pelvic portion of the ureter may be obtained also through a median hypogastric incision. This method, however, carries with it the danger of infection of the peritoneal cavity, especially if the ureter is distended with purulent urine.

Access to the *intravesical portion of the ureter* is obtained through the bladder. This viscus is opened above the pubes and, the edges of the wound being held apart, the floor of the bladder is inspected and palpated. Should there be a stone impacted in the intramural portion, the mucous membrane is incised over it and the stone shelled out with a scoop or director. It is not necessary to stitch the incision thus made unless brisk haemorrhage is encountered, when a catgut stitch on either side, uniting the mucous membrane of the ureter to that of the bladder, will suffice to control it.

Nephro-ureterectomy.—Excision of the kidney and entire ureter may be called for, especially in tuberculous disease, and is most efficiently effected through two incisions. The kidney is exposed first through a lumbar incision; it is completely mobilized and the vascular pedicle is ligated and divided. The ureter is freed downwards as far as possible but left intact. The kidney is brought out at the anterior end of the wound, the remainder of which is closed. The patient is then turned on his back and, through a median hypogastric incision, the ureter is exposed extraperitoneally. It is easily identified by putting traction on the kidney above. The ureter is completely freed down to the bladder, doubly ligated, and divided. The whole ureter, attached to the kidney, can now be withdrawn through the upper wound, which is completely closed. The lower incision is then sutured, a drain being inserted.

Ureterostomy.—When the entire bladder has to be removed on account of malignant disease, it may be necessary to establish a permanent urinary fistula in the loin, usually on both sides.

The simplest method of establishing the fistula is to expose the ureter through a gridiron extraperitoneal incision. The ureter, having been divided below the pelvic brim, is brought to the surface and united to the skin of the abdominal wall a short distance above the crest of the ilium (Fig. 222 A). The distal end of the ureter is ligated and its mucous membrane cauterized. No special risk attaches to the operation being carried out on both sides simultaneously. To prevent soiling of the clothing, an apparatus, such as that designed by Watson of Boston, must be worn, it consists of cup-shaped rubber hemispheres, fixed over the ureteral openings by straps, and connected with receptacles for the collection of the urine (Fig. 222 B).

Ureteral Anastomosis.—When the ureter has been intentionally or accidentally divided in the course of an operation, it may be re-

united by the invagination method introduced by van Hook. As usually performed, the vesical end of the ureter is closed, and lower down a longitudinal slit is made, into which the renal end of the ureter is inserted. The edges of the slit are then stitched all round to the wall of the portion implanted in it with fine sutures. This procedure may be carried out either trans- or extraperitoneally.



A B

Fig. 222. Ureterostomy.

A. Artificial urinary fistulae with tubes inserted.
B Apparatus for collection of urine

An alternative method consists in carrying out an end-to-end anastomosis of the ureter over a ureteral catheter which has been passed up from the bladder. The catheter may be left in for a few days

Implantation of the Divided Ureter into the Bladder.—In resections of the bladder for cancer it is sometimes necessary to sacrifice the lower portion of one or other ureter. The upper end must then be re-implanted through a fresh opening into the bladder—*uretero-cysto-neostomy.*

The simplest method available should be used, as it is impossible to provide an artificial uretero-vesical sphincter. The ureter is cut across and, by means of a silk suture, is pulled through a small opening made in the bladder wall, so that it projects 0·5 cm. ($\frac{1}{4}$ in.) beyond the mucous membrane of the bladder A row of interrupted catgut sutures is then inserted to unite the outer coat of the ureter

to that of the bladder, and a second row to unite the same coat of the ureter to the mucous membrane of the bladder. The orifice of the ureter may be split longitudinally for a short distance.

Implantation of the Ureters into the Intestine (Uretero-entero-anastomosis).—Under some circumstances it is found expedient to deviate the urine stream by implanting the ureters into the pelvic colon and thus establishing a cloaca. This is indicated in extroversion of the bladder, in certain cases of extensive malignant disease of the bladder requiring total cystectomy, and in extreme cases of vesico-vaginal fistula in which the vesical sphincter has been permanently destroyed. Prior to operation it is important to test the individual renal function by intravenous pyelography, as one or both kidneys may be diseased or a double ureter may be present.

Maximum abdominal relaxation is most helpful and for this reason spinal anaesthesia is usually employed. The method introduced by Coffey of Oregon is now most generally practised Both ureters may be dealt with simultaneously, or it may be deemed safer to carry out the operation in two stages, the right ureter being implanted first into the lower part of the pelvic colon, the left ureter being implanted a fortnight later into the upper part of the pelvic colon.

With the patient in the Trendelenburg position the abdomen is opened by a long midline incision and the intestines are packed off upwards. The ureter is exposed by dividing the peritoneum overlying the whole of its course through the pelvis; it is then isolated, divided at its lower end, and implanted into the colon. On the left side it is brought up through a puncture opening in the mesocolon so that it may approach the bowel from above and thus avoid tension. In its passage through the wall of the colon it is made to travel in the submucous layer for a short distance before penetrating into the lumen. The object of this is to form a mucous valve protecting its outlet. This is accomplished by making an incision about 2 cm. (¾ in.) long, through the serous and muscular coats of the colon and laying the ureter in the sulcus thus formed before it pierces the mucous coat at the lower end of the incision. The oedema which results from the operation has been found to produce occlusion of the lumen with transient anuria, and to obviate this C. H. Mayo modified the technique by inserting a wick of catgut which passes down the lumen of the ureter into the colon. The wound in the wall of the colon is closed over the ureter and, to prevent risk of its displacement, some of the stitches are passed through the outer coat of the ureter. A continuous Lembert suture of catgut is then inserted to cover these stitches. The incision in the peritoneum for the exposure of the ureter has previously been

sutured, and now the pelvic colon is anchored by suturing adjacent appendices epiploicae to the edges of the aperture in the posterior parietal peritoneum through which the ureter emerges. Thus all tension is avoided and a retroperitoneal course for the ureter is preserved.

At the conclusion of the operation and before the abdominal incision is closed, a well-lubricated rubber stomach tube is guided up the bowel to just below the level of the implantation, and continuous intravenous drip infusion is instituted. The urine is voided for some days through the tube into a bottle by the bedside, where it may be measured.

Implantation of the remaining ureter into the colon has been successfully employed in cases of progressive back-pressure due to an intractable tuberculous cystitis which has failed to heal though the primarily diseased kidney has been removed. In such patients the degree of hydro-ureter and hydro-nephrosis is so marked that it is frequently safer to carry out the operation in two stages—the first stage a nephrostomy and the second, about twelve days later, the implantation. If such precautions are not observed, there is a danger of an acute pyelo-nephritis developing.

H. W.

CHAPTER XXXI

OPERATIONS ON THE BLADDER

Anatomy. Diagnostic Technique. Drainage. Injúries. Vesical Calculi. Prostatic Affections. Deformities. Tumours.

Anatomy.—In the adult male the bladder when empty lies entirely within the pelvis As the organ fills, the fundus is projected upwards until the highest point lies above the pubic symphysis carrying with it the peritoneum of the anterior abdominal wall In the female the bladder lies more deeply in the pelvis, and when distended does not rise so high into the abdomen. In the child it occupies relatively a much higher level, and even when empty its anterior aspect is usually in contact with the abdominal wall. The bladder flattens when empty and becomes ovoid as it distends

Normally the bladder has a capacity of from 300 to 500 c.c. In the adult a bladder containing 450 c c. or more will raise the anterior peritoneal reflection from 2 to 5 cm. (1–2 in) above the level of the pubic symphysis. The anterior bladder wall may be punctured or incised through this 'bare area' without opening the peritoneal cavity The posterior peritoneal relations are constant because the peritoneum of the recto-vesical pouch is fixed and the posterior reflection is firmly attached to the rectum.

The bladder lies behind the pubic symphysis. Between the anterior wall of the bladder and the bone there is a space occupied by loose areolar tissue—the pre-vesical space—which readily becomes infected in urinary extravasation. The prostate lies below the bladder, and behind there lie the seminal vesicles, the juxta-vesical portions of the ureters, and the rectum. The upper and posterior surfaces of the bladder are covered by peritoneum and are in relation to the intestines

The bladder is enclosed by pelvic fascia, which is reflected to it and to the prostate from the levator ani as the rectovesical fascia. Anteriorly the pelvic fascia passes from the bladder to the pubis as the pubo-prostatic ligament. Superiorly the bladder is attached to the umbilicus by the urachus which is its superior ligament

The bladder wall consists of fibrous, muscular, sub-mucosal, and mucosal layers, and in addition the peritoneum covers the greater portion of its surface The *fibrous* coat consists of loosely arranged fibro-elastic tissue with a considerable amount of areolar tissue, at the base it blends with the pelvic fascia. The *muscular* coat consists of three layers of unstriated muscle—(*a*) the external longitudinal layer, (*b*) the middle circular layer, which is thicker than the external layer, with closely interlaced muscle-fibres, and (*c*) the internal layer, which is longitudinally arranged and is thin and inconspicuous. The [illegible] sphincter of the bladder is composed of looped fibres from [illegible] into the posterior urethra. The *sub-mucous* layer is made up of elastic fibres which loosely connect the mucous membrane with the muscular wall over the bladder surface as a whole, except at the trigone where it is more firmly [illegible] membrane is composed of transitional epithelium. It is

a few glands.

The bladder is described as having a vault or superior portion, two lateral walls, a base, and a trigone. The trigone extends from a base line between the two ureteric orifices to an apex at the bladder neck, where the trigonal muscle passes through the internal meatus to be inserted into the posterior urethra. A smooth ridge of muscular fibres stretches between the ureteric orifices—the inter-ureteral bar.

The terminal branches of the anterior divisions of the internal iliac arteries are distributed to the bladder mainly as superior and inferior vesical arteries. The middle vesical artery may be given off by the superior vesical artery or it may reach the bladder directly from the middle rectal, the obturator, or the internal pudendal and inferior pudendal arteries. The veins are arranged in a plexiform manner and empty into the internal iliac veins. On the anterior wall the prevesical veins receive the venous return from the penis and the veins in this part form a considerable prevesical plexus.

Lymphatics drain into nodes along the internal iliac and the hypogastric vessels

The sympathetic nerves of the bladder are derived from the first four lumbar sympathetic ganglia. These nerves are collected beneath the peritoneum over the fifth lumbar vertebra as the superior hypogastric plexus (pre-sacral nerve). Two hypogastric nerves emerge from this plexus, each of which ends in a

by branches from the anterior primary divisions of the second, third, and fourth sacral nerves which supply the parasympathetic fibres. From the anterior border of the hypogastric ganglia emerge a dozen or more branches of distribution to the bladder. These contain both sympathetic and parasympathetic nerves. The prostatic urethra and the external sphincter receive somatic fibres by way of the pudendal nerves which spring from the primary divisions of the third and fourth sacral nerves. The parasympathetic nerves

of the parasympathetic nerves lead to paralysis of the bladder.

Cystoscopy.—Cystoscopy is invaluable in the diagnosis of vesical conditions. The cystoscopic couch is usually fitted with the necessary equipment for taking radiographs. The examination is made most conveniently with the patient lying on his back with the head and shoulders raised and the thighs and knees partly flexed. It is an advantage to use a surface anaesthetic, such as 2 per cent anethaine injected through a urethral syringe, but when the

lotion and an estimate of its capacity is made. A bladder capacity markedly below 300 c c. is suggestive of an ulcerative lesion of the mucosa or infiltrating malignant disease. In cases of long-standing infection fibrosis and pericystitis lead to a permanently contracted bladder; it may be difficult to make an accurate diagnosis of the nature of intra-vesical lesions when the bladder capacity is greatly reduced. An increase in capacity suggests interference with emptying either from an obstructive lesion at the neck or from a neurogenic

the bladder cavity. The nature and site of diverticula, ulcers, tumours, calculi, etc., are noted as well as the position, number, and appearance of the ureteric orifices. The appearance of the neck is specially important in conditions of the prostate gland; thus a bulging contour is diagnostic of simple prostatic hypertrophy, whereas elevation of the posterior commissure suggests chronic fibrous prostatitis with contracture. An irregular nodularity is diagnostic of prostatic carcinoma Any form of obstruction to emptying leads to hypertrophy of the musculature which can be seen as a series of trabeculated ridges under the mucosa Relaxation of the neck, with funnel-shaped deformity, is a characteristic appearance in neurogenic disorders affecting the sacral posterior nerve roots.

Radiography.—Simple radiographs of the pelvic floor should be taken with the X-ray tube tilted in order that opaque bodies in the substance of the prostate should not be overlooked. In such radiographs the approximate position of each ureteric orifice is opposite the corresponding ischial spine. Cystograms are made after filling the bladder with 12 per cent. sodium iodide. Right and left oblique as well as antero-posterior views are taken. In the cystogram deformities at the bladder neck, enlargement of the prostate and relaxation of the bladder neck in cases of paralysis of the bladder may be recognized The oblique views are particularly valuable in demonstrating the size of diverticula. Filling defects in the contour of the cystogram may disclose the situation and extent of vesical tumours Intravenous urography can be employed to make cystograms of the bladder and to demonstrate residual urine.

Cystoscopy should not be carried out during the acute stage of infections of the urinary tract, nor is it possible in certain cases of urethral stricture or stone or when, owing to prostatic hypertrophy, there is marked elongation of the prostatic urethra.

Cystometry.—Cystometry is a means of recording graphically the pressure within the bladder, whereby the reflexes can be studied. In the normal cystometrogram the close sequence of the sensation of the desire to void and the contractions of the bladder muscle are noted and recorded when a bladder capacity of between 300 and 500 c c has been reached. The normal cystometrogram and the altered graphic record obtained in cases of neurogenic or myogenic disturbances of the bladder sufficiently contrast in type to be of diagnostic and prognostic value. By calibrating the graphic record the intravesical pressure can be shown both when the bladder is at rest during filling

of the bladder the detrusor muscle may be tonic and active, or atonic and weakened from stretching A distended bladder with an increased intravesical tension leads to backward pressure on the upper urinary tract and the danger of regurgitation of urine to the ureter, should the ureteric orifices become incompetent. In the atonic bladder, damage to the upper urinary tract from backward pressure may have o
the detrusor muscle ensued. I
withheld until renal function
below 50 mg per cent. intravenous pyelograms may be used to show any dilatation of the renal pelves and ureters. When the blood urea is considerably elevated there is not likely to be sufficient concentration in the kidneys of the contrast medium to give adequate radiographs.

Drainage of the Bladder.—When there is retention of urine and the urethra is permeable, the bladder may be emptied by catheterization *per*

urethram. This may be done intermittently or continuously. It is important to empty the bladder at eight-hourly intervals if over-stretching of the detrusor muscle with consequent loss of tone is to be avoided. For continuous urethral drainage an indwelling ureteral catheter is secured in position by a method which does not constrict the penis, and which permits the secretions of the urethra to escape alongside the catheter. The dressing at the external meatus should be changed at frequent intervals to prevent a collection of dried secretion damming up the urethra and so encouraging ascending infection. When continuous catheter drainage is employed, the genitals should be shaved and the penis and catheter protected by sterile dressings from contamination by the bedclothes. The prepuce and the glans penis must be treated with the same aseptic care as an open wound. A Foley's catheter is a simple and effective instrument for continuous urethral drainage when the terminal balloon is distended with 3–5 c.c. of lotion; a self-retaining catheter of this type does not require retentive strapping.

When drainage of the bladder is likely to be continued over a lengthy period, or when urethral drainage is considered inadvisable for other reasons, such as inadequate supervision, suprapubic cystostomy provides the safest method of drainage. The suprapubic catheter may be of the de Pezzer or Malecot type. A No. 16 catheter is usually employed, but in the presence of blood clot it may be necessary to use a wider bore drainage tube, such as a modified Freyer's tube. When suction is employed for drainage of the bladder it is an advantage to use a drainage tube with outer and inner components, otherwise the mucosa may be damaged by being drawn into the eye of the tube. In hospital practice suction by electric motor pump or by a vacuum ward fitting has entirely superseded older methods using the Bunsen system of bottles.

Bladder Lavage.—When lavage is necessary for chronic infective conditions of the bladder wall, particularly when there is phosphatic incrustation, or for the prevention of contracture in paresis, the tidal method has come to supersede intermittent washing-out of the bladder. The object of tidal lavage is to provide rhythmic filling and complete emptying of the bladder at regular intervals, and at the same time to bring the therapeutic agent, whether it be a phosphatic solvent or a urinary antiseptic, into intimate contact with the vesical mucosa by admixture with the urine. The irrigating fluid must be free from irritant qualities when used as a solvent for phosphatic incrustation, and the following formula, known as Solution G, has been found effective: citric acid, 32.25 gm.; magnesium oxide, 3.84 gm.; sodium carbonate, 4.27 gm., water, 1,000 c.c. For tidal lavage in the infected bladder 1:1,000 proflavine solution is employed. In *B. proteus* and *B. pyocyaneus* infections ½ per cent. acetic acid is the most efficient solution, but it must be used with caution. It is important to regulate the filling and complete emptying of the bladder with rhythmic periodicity. Wells's modification of the double Y tidal lavage system has been found to provide the most efficient syphonage. In the neurogenic bladder tidal lavage has proved of great value as a means of preserving rhythmic vesical filling and emptying until normal function of the detrusor muscle returns, or until it is replaced by autonomous or reflex activity. By

training in the process of rehabilitation may make them continent. The bladder is emptied at intervals of three hours 'by the clock', using, if necessary, accessory abdominal muscles in order to strain and so to make the emptying complete.

Catheterization.—The passage of a catheter may be used as a diagnostic measure to ascertain the patency or continuity of the urethra in cases of suspected injury or stricture When there is reason to suspect suppression of urine as opposed to retention, catheterization may be required. An accurate estimation of residual urine can be arrived at only by catheterization immediately after the patient has voluntarily passed urine. For a bacteriological examination of the urine it is unnecessary to catheterize the male. The collection of three-glass samples into sterile containers will suffice if the external meatus and the glans penis have been cleansed.

As a therapeutic measure catheterization is done for the relief of retention As the distended bladder, particularly when the distension is due to a spinal lesion, is specially prone to infection and cystitis, every precaution must be taken in using a catheter to avoid infection. Post-catheter fever, or even the introduction of infection to the urinary tract without systemic disturbance, may interfere with the successful treatment of the underlying cause of the obstruction or retention. Not infrequently in a debilitated patient cystitis is followed by sapraemia, pyelonephritis, and death

If the passage of a catheter is regarded as a minor surgical operation, and is carried out with similar attention to detail and aseptic technique, no undesirable consequences need be feared

There are available many types of rubber catheter—some with a coudé beak, some probe-pointed, some multiple-eyed or whistle-tipped. Thus it is rarely necessary to employ gum elastic or metal instruments. The passage of a rubber catheter lubricated with sterile oil is more easily borne by the patient and it causes least injury to the urethral mucosa. Intermittent catheterization for the paralysed or neurogenic bladder is universally condemned. In such cases high oblique suprapubic catheter drainage may be employed, or an indwelling urethral catheter may be inserted and used with tidal lavage The method of choice will depend largely on the circumstances of the case, the presence of accompanying abdominal lesions, the need for transport, and the availability of nursing facilities for the supervision of the catheter or drainage system employed Urinary sepsis can be controlled by a rigid aseptic technique The urine should be rendered slightly acid by such easily tolerated drugs as sodium or ammonium benzoate in gr xx doses. Sulphathiazole is given as a prophylactic, and the dosage adjusted according to the reports on the bacterial cultures from the urine Penicillin may be used when there is danger of contamination from penicillin-sensitive cocci

Preparation.—The parts should be washed, shaved, and smegma removed. Thereafter a non-irritating antiseptic such as picric acid solution or tincture of merthiolate should be applied to the external genitalia. With the patient [illegible]

[illegible]

biniodide of mercury; Nos. 8, 10, and 12 on the English scale, and Nos 18, [illegible] the French scale are the most suitable Rubber catheters may [illegible] Terminal [illegible] curved tip with lateral openings The tip is conical and reinforced, and the instrument [illegible] retention where a middle lobe hypertrophy predominates [illegible]

A bicoude curved gum elastic catheter may negotiate most readily [illegible] resistant obstruction in the posterior urethra, such as is found in carcinoma

of the prostate. The metal catheter with the so-called prostatic curve is most valuable in the larger prostatic hypertrophies when retention is accompanied by congestion and the presence of some blood clot in the urethra.

Passing the Catheter.—Premedication with morphine and atropine, or with barbiturate drugs, makes instrumentation much easier for the patient; the instillation of a few cubic centimetres of 1 per cent. anethaine may also be helpful. If the external meatus is small it should be slit after the injection of a local anaesthetic. A lubricated catheter is passed in a continuous movement, but pausing, if there is resistance at the external sphincter, *till that* muscle relaxes, thereafter continuing with a constant even pressure. Catheter lubricants must be applied liberally to the length of the instrument.

Suprapubic Aspiration of the Bladder.—In cases of retention of urine in which it is impossible to pass a catheter and the patient is in severe pain, temporary relief may be afforded by tapping the bladder above the pubis when the bladder is obviously distended. A small wheal of local anaesthetic is raised in the midline 7·5 cm. (3 in.) above the pubis, and a lumbar puncture needle is then introduced obliquely downwards and backwards to enter the bladder below the peritoneal reflection. After emptying the bladder the needle may be withdrawn and during withdrawal 100,000 units of penicillin in solution should be introduced to the prevesical space through which the needle passed. Suprapubic aspiration may be repeated once or twice at eight-hourly intervals *only until facilities are available for open operation.*

Operation for Rupture of the Bladder.—Rupture of the bladder is usually attended with severe shock, which is increased if there is subsequent extravasation of urine or concomitant injuries elsewhere. Steps must be taken to counteract this before and during operation. The choice of anaesthetic will depend on the general condition of the patient; it is imperative to maintain the blood-pressure and guard against anoxia.

Intraperitoneal Rupture.—After preparation of the abdomen and external genitalia a midline suprapubic incision 12 cm. (5 in.) in length is made and the peritoneal cavity is opened. As a rule the rupture is at the apex of the bladder, and presents as an irregular tear exuding urine mixed with blood. The bladder and peritoneal cavities are cleansed and mopped dry. The tear is then closed in layers with catgut, the superficial layers including the peritoneal covering of the bladder. The peritoneal cavity is cleansed thoroughly and the parietal peritoneum is closed.

For temporary drainage of the bladder the peritoneal reflection on the anterior wall can be dissected up intact for 2·5 cm. (1 in.) or more, and a de Pezzer catheter inserted through a stab incision in the bladder wall. Drainage *per urethram* can be carried out with a whistle-tipped rubber catheter, retained in position by a thread passed through its eye and brought out at the abdominal wound where it is anchored to a glass rod.

The prevesical space is drained with rubber-dam tissue, and the abdominal wound is closed in layers.

Any associated injury to the intestine with contamination of the peritoneum must be dealt with.

Sixty to ninety cubic centimetres (2–3 fl. oz.) of 3·8 per cent. sodium citrate solution are run into the bladder by the catheter and a spigot is inserted. After closure of the abdominal wound the spigot is removed and the bladder contents are aspirated by a syringe. The fluid is found to be free from clots. A further 60 c.c. of citrate solution are instilled and the spigot is reapplied. As a rule removal of the spigot, aspiration of the bladder through the catheter, and replacement of citrate solution at two-hourly intervals will be necessary for the first twelve post-operative hours. Thereafter catheter drainage may be continuous to a receptacle.

Extraperitoneal Rupture.—In extraperitoneal rupture resulting from blunt violence to the anterior abdominal wall, or from fracture of the pelvis, the bladder is torn on its anterior wall below the reflection of the peritoneum, and the urine which escapes infiltrates the areolar tissue of the prevesical space and spreads to the anterior abdominal wall. The ordinary incision for suprapubic cystotomy gives access to the rent in the bladder; under favourable conditions the opening can be closed with sutures, a drainage tube is inserted into the bladder at its highest point. Prevesical drainage is provided by a small cigarette drain. When the wound in the bladder has been accompanied by contusion and the line of suture is imperfect, continuous suction is a safeguard against further extravasation and leakage.

Trigonal Tear.—Perforation of the base of the bladder may complicate fracture of the pelvis. Urine is extravasated into the pelvis and infiltrates widely, descending to the perineum through the torn perineal membrane or ascending to the prevesical space and the anterior abdominal wall. The bladder is opened by a midline suprapubic incision. Blood clot and loose fragments of bone are removed and the bladder is drained, no attempt being made to suture the tear. If urine burrows towards the perineum an incision must be made and drainage provided through the deep perineal space. The prevesical space is cleansed and a drain inserted. The wound is closed loosely with interrupted sutures. Following traumatic recto-vesical fistula, temporary colostomy and suprapubic cystotomy may lead to recovery, or the fistula may be closed later by the perineal route. Suction drainage of the bladder promotes closure of the fistula.

Suprapubic Cystotomy.—The suprapubic route is now almost universally adopted for the removal of a stone or a tumour, for operations on the neck of the bladder, for the enucleation of an enlarged prostate, and to establish drainage in infective conditions. The bladder may be opened suprapubically under local anaes-

thesia, but for most intravesical procedures a general anaesthetic is required. Spinal anaesthesia gives complete relaxation which facilitates inspection and manipulation of the bladder base, but may be attended with fall in the blood-pressure leading to circulatory disturbances and anoxia, and a severe degree of shock.

In infected cases irrigation with 1:10,000 silver nitrate lotion may be beneficial. Unless it is already dilated, the bladder is filled with

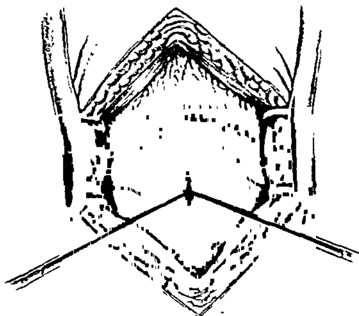


FIG. 223 Suprapubic Cystotomy.

boric lotion through a rubber catheter till it becomes palpable above the pubis. The connecting tube to the catheter is clamped. A midline suprapubic incision is made and the anterior rectus sheath divided. The line of separation between the recti is defined and opened up. The anterior bladder wall is exposed, covered by prevesical fascia below and by the peritoneum above. The lower limit of the peritoneal reflection is defined and dissected upwards (Fig. 223). If wounded, the peritoneum must be sutured at once. Prevesical veins liable to injury when the bladder is opened are individually ligated and divided, and the prevesical fascia is reflected downwards for a short distance. The bladder muscle is now picked up with forceps, and the bladder is allowed to empty through the catheter which has been retained in the urethra. The bladder is opened by a stab incision and its interior dried by swabs or by suction

A digital examination is made of the interior of the bladder, trigone, and vesical outlet. A self-retaining bladder retractor is inserted, and by means of suitable illumination the interior is inspected for any abnormality and to note the condition of the ureteric orifices and their state of activity. If the intravesical manipulations have caused bleeding, it is advisable to use a modified Freyer's tube to drain the bladder, otherwise a de Pezzer or Malecot self-retaining catheter will suffice. The bladder wall is closed in two layers by catgut sutures; the outer layer picks up the prevesical fascia. The prevesical space is dried out and drained by a small strip of rubber dam inserted through the lowest part of the incision, to avoid prevesical collection of blood or urine, which in infected cases would lead to pelvic cellulitis The suprapubic wound is closed in layers. The Freyer's tube is connected to a drainage system and suction is used when the intravesical operation has caused bleeding. Suction prevents clot formation within the bladder The prevesical rubber drain is removed three days after operation, and the Freyer's tube or de Pezzer catheter may be withdrawn after five or six days if the bladder is to be allowed to close

When the suprapubic wound is to be retained permanently (*suprapubic cystostomy*), the self-retaining catheter is fitted with a rustless metal flange which maintains it at a constant level. A body-belt is worn with a mesial opening which rests on the flange and keeps it firmly against the skin The catheter passes to a portable rubber urinal which is suspended from the belt. The fistulous channel soon becomes epithelialized

For the comfort of the patient, and to prevent incrustation of phosphates and deterioration of the rubber, the catheter should be changed every five or six weeks and the bladder washed out with a weak acid lotion If a new catheter is required it should be of the same size as the one removed, to prevent leakage and to maintain the accurate fitting of the flange

The catheter, with the introducer, is lubricated and passed into the bladder On withdrawal of the introducer the expanded end of the catheter should be free in the cavity without impinging on the bladder wall The flange is adjusted to retain this position.

If phosphatic crystals have collected on the base of the bladder, they can be dissolved with acetic acid ($\frac{1}{2}$ per cent.) solution.

The bladder is washed out several times with boric lotion before readjusting the collecting apparatus, after it has been thoroughly cleansed

When there is no infection and consequent contracture of the bladder, the suprapubic tube may be occluded with a spigot and continuous drainage to a bottle is used only at night

Chronic Retention of Urine with Dilated Bladder.—When suprapubic cystotomy has to be performed in cases of dilated bladder with symptoms of renal backward pressure, certain modifications in the technique are necessary. Local anaesthesia alone or in combination with a narcotic, or cyclopropane and oxygen, may be used. The bladder is exposed by a midline suprapubic incision, bringing into view the prevesical fascia with its accompanying veins. The degree of intravesical tension in a distended bladder varies considerably. During normal filling the bladder pressure is from 5 to 15 cm. water. During a contraction the intravesical pressure may rise from 60 to 80 cm. water. A graduated glass tube attached to the suprapubic tube will register the height of the intravesical pressure. This figure may be used as a guide as to the necessity for gradual decompression or for drainage. The bladder is punctured by a trocar and cannula, and a de Pezzer or Malecot catheter with its introducer is inserted; leakage of urine is avoided as far as possible. A few cubic centimetres of urine are withdrawn, and the tube is clipped. The wound is loosely closed by interrupted sutures, prevesical drainage being provided for by a strip of rubber.

Gradual decompression is now carried out by means of continuous drainage against resistance. Usually the collecting bottle is placed at a higher level than the pubis of the patient so that the urinary stream has to be forced uphill. The height of the bottle is so regulated that urine trickles over from the tube as a series of drops coming in quick succession. The bottle is lowered at intervals in order that this regular overflow may be maintained continuously. Usually some four or five days pass before the bottle is at floor-level and complete decompression has been achieved. Alternatively the end of the drainage tube may be closed by a spigot, and a small intravenous needle inserted through the tube to its lumen immediately above Again the urinary outflow is regulated by the bore of the needle so that it escapes at the rate of 60 drops each minute. At least 2,000 c c. of fluid are given every twenty-four hours, by the mouth or intravenously. The general condition can be assessed by the urinary output, the state of the tongue, and by estimating the blood-urea nitrogen.

Sometimes chronic distension of the bladder occurs in cases of congestive heart failure with oedema when the relief given by drainage of the bladder, and the response of the patient to cardiac restoratives, will lead to diminution of the oedema, and thus justify a more rapid rate of urinary drainage, while the intake of fluid by mouth may be restricted to 1,000 c.c in the twenty-four hours.

Suprapubic Lithotomy.—Suprapubic cystotomy is performed and the interior of the bladder inspected in its entirety with the

aid of good illumination and adjustable self-retaining retractors. The stone or stones are removed by lithotomy forceps or scoop. Diverticula should be explored when present, and the neck of the bladder examined for pathological changes such as follow prostatic enlargement. Any obstructive lesion should be dealt with at the same time or at a later date The bladder is drained for a few days by means of a self-retaining catheter or a small Freyer's tube

Lithotrity and Litholapaxy.—Litholapaxy consists in crushing a vesical calculus with a lithotrite passed *per urethram*, and flushing out the broken fragments by means of a special evacuating attachment—the Bigelow evacuator. Litholapaxy is not now frequently performed for vesical calculus accompanying prostatic enlargement or diverticula formation, but the operation may be carried out when the calculus occurs in the absence of any gross obstructive lesion at the neck of the bladder

Local, caudal, or general anaesthesia may be employed. The best position of the patient is on the cystoscopic table, the separation of the thighs permitting the operator to check the progress of the operation by cystoscopy A slight degree of Trendelenburg position is an advantage The bladder is filled with lotion, the cystoscope is passed, the stone is viewed, and its probable composition is judged from its appearance The lithotrite is now passed, the shaft grasped, and the instrument depressed on the posterior wall of the bladder An intravesical hollow is thus formed into which the stone will move. The female blade remains fixed as the jaws of the instrument are opened, and the stone falls between them With the instrument held vertically the blades are closed on the stone, and their grip is judged by moving the male blade Any resistance to rotation of the instrument indicates that mucous membrane has been included, when the lithotrite must be opened and the bladder wall released The stone and larger fragments are broken up until they are small enough to be removed The evacuating catheter is then passed, the Bigelow evacuator attached, and the bladder flushed out until fragments cease to fall into the glass bowl Repeated alternate crushing and evacuation are carried out at one sitting until the operation is completed The operation should not be continued if bleeding occurs Post-operative recovery is rapid, and the patient may be allowed up and about whenever the urine is clear The reaction of the urine should be kept acid by ammonium chloride given as cachets in 15-grain doses three or four times daily.

Suprapubic Prostatectomy.—The operation may be carried out in one or in two stages depending on the degree of renal backward pressure present The one-stage open method is the operation of choice if the condition of the patient is satisfactory

Prostatectomy as carried out by Freyer in 1900 was a blind procedure which in his hands yielded excellent results. During the past forty years several factors have led to the adoption of modifications of the original technique.

1. The recognition of impairment of renal function due to backward pressure from obstructions at the bladder neck, or from upper urinary tract lesions, depends on the complete investigation of the patient before operation. Estimations of the level of nitrogen retention in the blood, radiographic examination, and the intravenous pyelogram, have enabled the renal reserve available to the patient in the immediate post-operative period to be assessed.

2. Although most types of prostatic obstruction may be recognized by rectal examination, cystoscopy and radiography together supply information which should indicate whether the prostate is enucleable, as in simple hypertrophy, or whether, as in cancer or fibrous prostatitis with prostatic calculi, a line of cleavage will not be found.

3. Illuminated retractors permit accurate inspection of the bladder neck and enable the removal of the gland to be completed under direct vision. The operation field should not be obscured by blood, which is removed by suction.

4. The control of haemorrhage by diathermy or by ligation of bleeding-points in the prostatic bed limits shock from blood loss. At the same time freedom from packing in the prostatic bed reduces post-operative pain and the dangers of secondary haemorrhage when the pack is removed.

5 Modern anaesthesia with the maintenance of full oxygenation permits a more deliberate operative technique than was formerly possible.

6. The availability of supplies of stored blood enables blood loss to be replaced as it occurs on the operating-table.

7 By employing suction apparatus the asepsis of suprapubic bladder drainage is more assured, with freedom from wound leakage and sodden dressings; the more general use of the sulphonamide drugs and penicillin favours asepsis.

8. Closure of the bladder after prostatectomy and reliance on an indwelling urethral catheter for drainage have been rendered possible by haemostasis at the field of operation; the immediate return of adequate urinary secretion by rapid transfusion; and the prevention of blockage of the catheter by clot by the instillation of sodium citrate solution to the bladder for the first few hours after operation each time the catheter has been released, which is every hour. The post-operative course is shorter and less painful. The patient may be up with restoration of normal micturition ten days after the operation

aid of good illumination and adjustable self-retaining retractors. The stone or stones are removed by lithotomy forceps or scoop. Diverticula should be explored when present, and the neck of the bladder examined for pathological changes such as follow prostatic enlargement. Any obstructive lesion should be dealt with at the same time or at a later date. The bladder is drained for a few days by means of a self-retaining catheter or a small Freyer's tube

Lithotrity and Litholapaxy.—Litholapaxy consists in crushing a vesical calculus with a lithotrite passed *per urethram*, and flushing out the broken fragments by means of a special evacuating attachment—the Bigelow evacuator. Litholapaxy is not now frequently performed for vesical calculus accompanying prostatic enlargement or diverticula formation, but the operation may be carried out when the calculus occurs in the absence of any gross obstructive lesion at the neck of the bladder.

Local, caudal, or general anaesthesia may be employed. The best position of the patient is on the cystoscopic table, the separation of the thighs permitting the operator to check the progress of the operation by cystoscopy. A slight degree of Trendelenburg position is an advantage. The bladder is filled with lotion, the cystoscope is passed, the stone is viewed, and its probable composition is judged from its appearance The lithotrite is now passed, the shaft grasped, and the instrument depressed on the posterior wall of the bladder. An intravesical hollow is thus formed into which the stone will move The female blade remains fixed as the jaws of the instrument are opened, and the stone falls between them. With the instrument held vertically the blades are closed on the stone, and their grip is judged by moving the male blade. Any resistance to rotation of the instrument indicates that mucous membrane has been included, when the lithotrite must be opened and the bladder wall released. The stone and larger fragments are broken up until they are small enough to be removed. The evacuating catheter is then passed, the Bigelow evacuator attached, and the bladder flushed out until fragments cease to fall into the glass bowl. Repeated alternate crushing and evacuation are carried out at one sitting until the operation is completed. The operation should not be continued if bleeding occurs. Post-operative recovery is rapid, and the patient may be allowed up and about whenever the urine is clear The reaction of the urine should be kept acid by ammonium chloride given as cachets in 15-grain doses three or four times daily

Suprapubic Prostatectomy.—The operation may be carried out in one or in two stages depending on the degree of renal backward pressure present. The one-stage open method is the operation of choice if the condition of the patient is satisfactory.

lobes and the posterior lobe is next defined. Care must be taken that the posterior lobe and ejaculatory ducts are not damaged and that the false capsule is left intact; if the wrong line of cleavage is struck, the posterior lobe may be separated and total prostatectomy inadvertently carried out. The line of cleavage would then pass between the capsule and the prostatic sheath, and the prostatic venous plexus would be opened. The lobes of the prostate surrounding the prostatic urethra have now been separated, and it remains to break through the mucosa of the urethra at the anterior limit of the hypertrophied prostatic tissue and dislodge the prostate from its bed. The middle lobe is easily separated from the underlying false capsule and the prostate is removed. Occasionally the mucosa of the base of the bladder remains adherent to the vesical surface of the median lobe of the prostate. To prevent undue stripping of the mucosa, it may be advisable to divide the mucous membrane at this point with scissors.

Slight modifications in method have been introduced by individual operators, according to the predominance of lateral or median lobe hypertrophy: some prefer to begin the enucleation anteriorly from within the prostatic urethra.

The prostate having been removed, a gauze swab is pushed into the prostatic cavity, and bladder retractors are inserted. The patient is placed in the Trendelenburg position, and satisfactory illumination of the interior of the bladder is obtained. The swab is removed, and the prostatic cavity is inspected for tags, flaps, or nodules of capsule, mucosa, or prostatic tissue, which are excised, as they may lead to obstruction or valve formation. Bleeding vessels are sought for; two fairly constant vessels are found on either side of the vesico-prostatic entrance. These may be secured by artery forceps, and occluded by catgut sutures. In certain cases this haemostatic suture may be continued round the vesico-prostatic margin to ensure the complete control of haemorrhage at the bladder neck. To check oozing the cavity is packed firmly by a gauze roll wrung out of liquid paraffin. A Freyer's drainage tube is inserted, and the bladder wound closed by two superimposed layers of catgut sutures. The prevesical space is drained.

The immediate post-operative treatment varies in minor details in individual cases. The drainage tubes are watched for blockage. There is serious danger of extravasation of blood and urine into the prevesical space unless the drainage system is kept clear. Light suction is usually commenced immediately after the operation. Fluid is given by mouth or intravenously, according to the state of the patient and the anaesthetic that has been employed. It is essential that the excretion of urine should be encouraged from the

Spinal or complete general anaesthesia gives the necessary relaxation. The bladder is opened as in suprapubic cystotomy. A digital examination of the neck of the bladder follows. The prostate is examined and the floor is explored for a retroprostatic pouch or a calculus The consistence and size of the prostate are determined. Inspection of the floor of the bladder may be carried out with the aid of self-retaining retractors and suitable illumination. Prior to



Fig 224 Suprapubic Prostatectomy.

enucleation, the retractors are removed, and a single tissue forceps secures the bladder wall. The position of the patient and the complete relaxation should enable the operator's finger to pass into the bladder without being restricted by extravesical pressure. The line of demarcation between the prostate and the bladder neck is sought for with the finger. This varies in different cases, and depends on the degree of hypertrophy in the component lobes of the prostate. The lateral aspect of the neck is that usually chosen. The mucous membrane over the hypertrophied lobe is broken through by digital pressure and the plane of cleavage between hypertrophic prostatic tissue and the mucosa is defined (Fig. 224). The finger sweeps on each side, separating the lateral lobes, then forwards defining the anterior lobe to its anterior limit. Passing downwards, forwards, and then posteriorly the line of cleavage between the lateral and median

especially as visual inspection for bleeding-points is usually impracticable in such cases. With the pack in position, the operation is completed by the insertion of a Freyer's tube and closure of the wound by loosely tied interrupted sutures.

The treatment of the bladder neck after enucleation of the prostate is dependent on adequate illumination.

1. The middle lobe may have been retrotrigonal, so that after enucleation an elevated shelf persists, which if left alone will form one of the commonest causes of post-prostatectomy obstruction. The redundant postero-inferior lip of trigone may be excised in a wedge-shaped manner, and subsequently a series of interrupted catgut sutures passed from the trigone to the prostatic capsule, so that the vesical outlet is smooth and rounded. Such sutures often are sufficient to control haemorrhage adequately.

2. Many surgeons prefer to obliterate the raw surface of the prostatic bed by re-trigonization of the prostatic urethra This is done by passing a suture from behind the interureteric bar underneath the trigone and false capsule of the prostate to the apex of the prostatic urethra. This suture, as it is tied, pulls the trigone down into the prostatic bed to reconstitute its floor. The needle employed is of the boomerang pattern (Harris). Similarly the antero-lateral aspects of the prostatic capsule are inverted by figure-of-eight catgut sutures. The raw surfaces of the prostatic urethra should now be obliterated without dead space. With haemorrhage controlled and a new prostatic urethra constituted by this plastic treatment, a rapid convalescence may be obtained, with excellent results. Many surgeons close the bladder incision and rely on an indwelling urethral catheter for drainage

[illegible] haemorrhage.

3. The converse of re-trigonization is excision of the trigone. The removal of this muscle is carried out by scissors-dissection. The ureteric orifices are left intact but the line of excision is carried distally to the prostatic urethra at its widest point. The prostatic bed is now widely open for inspection, and by using the sucker and the malleable lamp, the vessels of the prostatic capsule may be seen and subsequently sealed by diathermy. A whistle-tipped catheter is employed for urethral drainage, and the incision in the anterior bladder wall is closed

4 Retropubic prostatectomy (Millin) is carried out without opening the bladder wall. The anterior aspects of the prostatic sheath and capsule are incised transversely just behind the pubis. The

first; maintenance of the blood-pressure level and diuresis are obtained by an increased fluid intake averaging 2,000 c.c. in the twenty-four hours. Blood loss should be made good by blood transfusion. The prevesical drain is removed on the third day and the pack in the prostatic cavity on the sixth day. The liquid paraffin should permit of the pack being removed without bleeding. The Freyer's tube is removed at the end of the first week. The passage of urine by the normal channel may return immediately after the pack has been removed, or may be delayed. No instrumentation of the urethra should be attempted for at least three weeks after the operation The passage of a urethral bougie often sets up epididymitis. Undue haemorrhage is exceptional, and is manifested by soakage at the wound, intravesical clotting, and rapidity of the pulse. This is a serious complication: the blood loss accompanied by clot retention leads to profound shock A blood transfusion should be given, and under general anaesthesia the drainage tubes should be removed, the wound enlarged, and the clots evacuated. Irrigation of the bladder with warm lotion is usually sufficient to arrest the bleeding as the bladder musculature contracts The Freyer's tube may be replaced, but it is usually an advantage to continue a drip irrigation through a urethral catheter as a safeguard against recurrence

Two-stage Method.—The *first stage* consists of suprapubic cystotomy followed by decompression of the urinary tract. The second stage is carried out not less than ten days later, or it may be delayed for weeks or months, depending on the general state of the patient and the results of the various tests for urinary function.

Second Stage: 'Blind Prostatectomy'.—Spinal anaesthesia is of great value in the second stage of the operation when the contraction of the bladder following drainage, and induration of the wound from the previous operation, offer resistance to the intravesical manipulations.

The existing suprapubic wound is excised. Care must be taken to avoid injury to the peritoneum if upward extension is attempted. It is for this reason that at the original cystotomy the peritoneal reflection is dissected upwards for 5–8 cm. (2–3 in.). The margins of the rectus muscles are defined and the bladder walls mobilized as far as possible. Enucleation is carried out in a manner similar to that described in the one-stage open method, but owing to the resistance of the margins of the abdominal wound it may be difficult for the finger to reach the anterior limit of hypertrophy in the prostatic urethra. A finger of the other hand in the rectum may be of great assistance in keeping the prostatic bed against the enucleating finger and ensuring complete removal By keeping the finger in the rectum the prostatic cavity may be packed more securely,

especially as visual inspection for bleeding-points is usually impracticable in such cases. With the pack in position, the operation is completed by the insertion of a Freyer's tube and closure of the wound by loosely tied interrupted sutures.

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urethral catheter hourly in the immediate post-operative period. Bladder lavage followed by the instillation of 30 c.c. of 3·8 per cent. sodium citrate should enable continuous urethral drainage to run satisfactorily within a few hours of the operation.

Endoscopic Resection of the Prostate.—*Operation for Contracture of the Bladder Neck, Simple Hypertrophy, and Carcinoma of the Prostate.* Transurethral resection of the prostate or the bladder neck has now a wide application in the treatment of obstructive lesions. It is the operation of choice in chronic fibrous prostatitis with contracture or median bar, and middle lobe or posterior commissural hypertrophy of the prostate. When a prostatic carcinoma produces symptoms of obstruction with dysuria, endoscopic resection with widening of the prostatic urethra may restore normal micturition. When a successful resection is followed by dienoestrol in large doses of 30 or 40 mg. daily, normal micturition may be maintained for a number of years. The treatment is palliative and metastases may still appear, but oestrogens definitely inhibit the activity of the malignant cell and in some cases appear to bring about actual recession.

Two methods of resection are employed. In both the instrument is passed *per urethram* and the cuts are made under vision; bleeding-points are arrested by the direct application of a diathermy electrode. In diathermy loop resection the cut is made from the bladder neck distally to the verumontanum, by a wire loop-electrode conveying a high-frequency cutting current. The sheath is insulated by bakelite, and the loop carrier is seen and the length of cut controlled through a direct-vision telescope. In prostatic punch resection the cut is made by a tubular knife which operates within the sheath under visual control. The cut is made from the apex of the prostate proximally. Bleeding-points are controlled by diathermy coagulation under direct vision With the punch method it is possible to resect large adenomatous prostates. The diathermy loop resection is more suitable for smaller obstructing lesions. A low spinal or a general anaesthetic may be employed. It is important to guard against excessive blood loss and to complete the operation within one hour. At the conclusion of the operation a whistle-tipped catheter is tied in *per urethram.* Bladder lavage is carried out at hourly intervals until a free urinary flow is established. After the first twelve hours there should be no danger of blood clot obstructing the catheter, and bladder lavage may be reduced to two or three times in twenty-four hours. The indwelling catheter may be removed when the urine is clear, usually on the fifth day. With the return of normal micturition, the patient may be allowed up.. Preliminary drainage of the bladder in cases of impaired renal function or urinary

margins of the capsule are secured by special forceps to control the vessels, and as the capsule is stripped upwards and downwards by scissors-dissection the hypertrophied prostate is exposed and removed. The inferior lip of the trigone is excised to prevent shelf formation. Using special retractors, the sucker, and a malleable lamp, the prostatic cavity is now examined for bleeding points, which are sealed by the diathermy current. A catheter is tied in *per urethram*. Haemostasis is finally secured by mattress sutures of the capsule and the sheath of the prostatic urethra. The abdominal incision is closed in the usual manner.

Operation for Median Bar—Fibrous Prostate—Contracture of the Bladder Neck.—In many cases of obstruction at the neck of the bladder no appreciable hypertrophy of the prostate is present. When the bladder is opened suprapubically it is found that the internal vesical meatus is contracted, the ring is fibrous, and the trigonal muscle hypertrophied. The interureteric bar may be thickened with retrotrigonal pouch formation. If the internal vesical meatus is dilated by the insertion of forceps and the blades are separated, the prostatic urethra may be examined digitally. There is no true hypertrophy of the lateral lobes to be felt in the prostatic urethra, and on inspection no middle lobe may be seen herniating into the bladder cavity. Dilatation of the bladder neck in such circumstances is insufficient, as the fibrosis and inelasticity are of a progressive nature. The contracture may be best overcome by resecting the trigone by a wide V-shaped excision commencing at the centre of the interureteric bar. Suitable retractors and illumination enable the operator to incise distally to the ureteric orifices, and to continue the dissection into the prostatic urethra at the junction of the lateral margins of the meatus with the posterior commissure. With suction and illumination, spheroids of true middle lobe hypertrophy now exposed may be dissected out, or enlarged Albarran glands in the mucous membrane of the posterior commissure excised with the trigonal wedge of tissue. The prostatic urethra has been thrown widely open and the two arterial bleeding-points at 5 and 7 o'clock at the entrance may be caught by artery forceps and sealed by diathermy. Smaller vessels are similarly sealed so that no packing or buried sutures need be employed which might lead to further fibrosis at the vesical outlet. Drainage of the bladder by an indwelling whistle-tipped urethral catheter will usually prove adequate, and the bladder may be closed without suprapubic drainage. The immediate after-treatment is directed towards the stimulation of urinary secretion and the prevention of clot obstruction in the urethral catheter. This may best be undertaken by rapidly administering two pints of glucose saline intravenously, and attending to the

injury. The inferior recto-urethral muscle and its overlying fascia are exposed and divided anteriorly at their attachment to the bulb. The rectum can now be pushed backwards by blunt dissection, exposing in the depths of the wound the posterior layer of the recto-vesical septum (Denonvillier's fascia) attached to the membranous urethra and the perineal membrane. The fascia is incised, and the subjacent membranous urethra and the apex of the prostate are exposed. An incision is made into the urethra at the apex of the prostate and carried forwards, cutting on the sound, for a short distance into the membranous urethra. The sound is removed and a special two-bladed prostatic tractor is inserted through the opening in the membranous urethra into the bladder; the blades are separated and the prostate is drawn into the operation field. The prostatic surface is still covered by the posterior layer of the recto-vesical septum with some fibres of the levator ani on each side, and this fascia must be divided and pushed backwards so as to expose the shining anterior layer of the recto-vesical septum and to define the retroprostatic space. The posterior and lateral aspects of the prostate are now exposed. Deep incisions are made near the apex; they are bilateral and may be vertical or transverse. The hypertrophied lobes are freed by blunt dissection and removed. The vesical sphincter is examined, and vesical calculi, if present, removed with a scoop. A large drainage tube is passed into the bladder through the prostatic urethra, which is packed with gauze round the tube to secure haemostasis. The levator ani muscles are approximated by a catgut suture and the superficial wound by interrupted sutures, the drain passing to the exterior at one corner.

When the recto-vesical septum is found to be obliterated as in such conditions as prostatitis, prostatic calculi, and prostatic abscess, the incision through the prostatic capsule is limited to the extreme apex of the gland. The rectum is liable to injury if forceful stripping of the fascia is attempted. A small inverted U-shaped incision into the prostate is sufficient for drainage of an intralobar abscess and for the removal of calculi.

Perineal prostatectomy is well borne by elderly patients. There is little post-operative pain, and the perineal drainage is excellent. Confinement to bed need not be for more than a few days. Disadvantages arise when the external sphincter mechanism has been damaged by the insertion of prostatic retractors through the incision in the prostatic urethra at its apex. Although the perineal wound may be expected to heal rapidly and fistulae are rare, urinary incontinence is not uncommon. The operation has never been adopted widely in this country.

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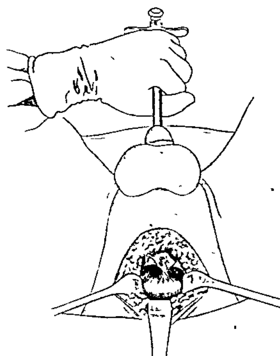


Fig 225 Perineal Prostatectomy

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ıal or general anaesthesia may be used. The placing of the t in an exaggerated lithotomy position is of importance, a perineal elevating shelf being used for this purpose. A sound been passed to the prostatic urethra, an inverted U-shaped n is made in the perineum The midpoint of the incision is (2 in.) in front of the anus. The central tendon and the fatty on each side behind the transversus perinei muscles are d. After the insertion of special retractors the central tendon vn taut and divided (Fig. 225). The dissection is carried deeply en urethra and rectum, both of which must be guarded from

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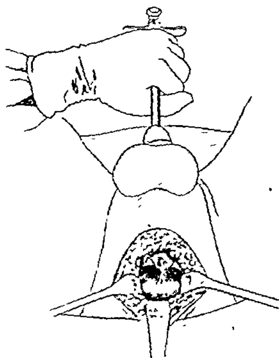


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Spinal or general anaesthesia may be used. The placing of the patient in an exaggerated lithotomy position is of importance, a special perineal elevating shelf being used for this purpose. A sound having been passed to the prostatic urethra, an inverted U-shaped incision is made in the perineum The midpoint of the incision is 5 cm. (2 in.) in front of the anus The central tendon and the fatty spaces on each side behind the transversus perinei muscles are

of all tumour cells. Haemostasis is secured by diathermy. Sessile papillomas are treated by fulguration alone. The bladder and wound margins are flooded with silver nitrate solution (1 : 1,000) in order to destroy any free tumour cells and to prevent re-implantation. A tube drain is inserted, and the bladder wound closed in layers round the tube. Papillomatous tumours which do not exceed 2·5 cm. (1 in.) in diameter may be destroyed by fulguration through the operating cystoscope. Endoscopic treatment may be employed for all such tumours which are limited in number and simple in type.

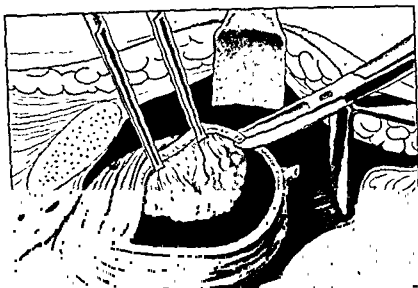


Fig. 226. Partial Cystectomy.

Two or three fulguration treatments may be necessary to destroy the more proliferative tumours. Follow-up examinations should be carried out at regular intervals subsequently to ensure the earliest possible detection of a recurrence.

Partial Cystectomy.—Malignant tumours of the vault are removed with the entire thickness of the bladder wall. A suprapubic incision is made, and the peritoneal reflection stripped back widely. The urachus is divided. The incision into the bladder is planned to avoid cutting tumour tissue. The entire thickness of the bladder wall including the tumour and a small margin of normal tissue is removed (Fig 226). The operation field is bathed with silver nitrate solution and the bladder wound closed with drainage.

A similar technique may be employed for excision of a portion of the vault and anterior wall of the bladder in cases of interstitial cystitis, or chronic solitary ulcer.

Hemi-cystectomy.—This operation is carried out for malignant

Prostate.—Young recommended total prostatectomy for carcinoma when the disease was recognized early and had not extended to the prostatic sheath. The incision and approach are as for simple perineal enucleation of the gland, but the dissection is continued higher, and the neck of the bladder is divided just below the entrance of the ureters. The prostate, its capsule, and its sheath are removed, if necessary, together with the seminal vesicles. The bladder neck is joined to the stump of the membranous urethra by a series of mattress sutures. An indwelling urethral catheter is employed both as a splint and to provide drainage.

Diverticulum of the Bladder.—Since obstruction in some form is nearly always the cause of the formation of diverticula, any obstruction must be removed In small multiple diverticula no further operative treatment is necessary. Occasionally a diverticulum causes symptoms either from its retained infected content or from calculus or tumour formation within it. Radical removal of the diverticulum is then the operation of choice.

Spinal or general anaesthesia may be employed. A wide reflection of the peritoneum is made prior to opening the bladder The interior of the bladder is inspected, and the relation of the ureteral orifices to the mouth of the diverticulum is noted In certain cases the diverticulum may be drawn into the bladder by suction or with forceps. After its mucous membrane has been separated and removed, the vesical opening is closed by catgut sutures. In the extravesical operation the peritoneum is stripped from the bladder wall. The diverticulum is packed with gauze and converted into a solid pedunculated tumour (Lower) This is defined extravesically and removed The circular opening in the bladder wall that remains is closed by two layers of catgut sutures The extravesical tissues and the prevesical space are both drained When the ureter opens into the fundus of a diverticulum, re-implantation of the ureter into the bladder is necessary after removal of the diverticulum The ureter is lightly secured to the bladder wound by fine interrupted catgut sutures and ample extravesical drainage is provided. The bladder is subsequently drained by a suprapubic tube Suction is applied to keep the bladder empty and contracted

Operations for Vesical Tumours.—The bladder is opened suprapubically. If the tumour is situated on the roof, the incision is so placed as to avoid its passing through tumour tissue The interior of the bladder is inspected and the site and nature of the tumour are determined Simple and transitional papillomatous tumours are removed by applying curved forceps to the base of the growth and removing the pedicle with a small margin of healthy mucosa. The base is treated by fulguration to ensure the destruction

for where it crosses the common iliac artery, and the peritoneum of the posterior abdominal wall is incised vertically along its length. The lowest limit of the ureter in its intrapelvic course is defined, and the ureter ligated distally and divided. The ureter is examined for evidence of infection. In the technique of C. H. Mayo, a single intraluminar suture of fine catgut is inserted into the cut end of the ureter and tied. The shorter end is then threaded for a few inches up the ureteral lumen to act as a wick, which will maintain urinary excretion into the bowel after transplantation. The longer end of the suture with the needle attached is laid aside. The sigmoid portion of the pelvic colon is brought forward, and a point chosen on its antimesenteric border to which the divided ureter can be brought without tension. The loop of bowel is lightly clamped to prevent leakage, and an incision 7·5 cm. (3 in.) in length made through the longitudinal band. This incision divides the serous and muscular coats only, the mucosa being preserved intact. The lumen of the bowel is opened by a stab incision at the distal end of the submucous channel thus formed, and the ureter is drawn into the opening and secured by the attached needle and suture to the bowel wall 2·5 cm. (1 in.) distal to the stab opening. The margins of the submucous channel are closed over the ureter by two layers of sutures. Every second stitch of the first layer passes through the adventitia of the ureter in order to fix it securely. The incision in the posterior parietal peritoneum is closed up to the opening where the ureter enters the peritoneal cavity, and the colon is anchored by appendices epiploicae to the posterior abdominal wall at this point to prevent kinking of the ureter as it enters the bowel. By this means also the retroperitoneal cellular tissue plane is protected against infection. The peritoneal cavity is closed without drainage. In the post-operative period enemata are avoided owing to the danger of regurgitation up the ureter. Urine is collected from the rectum by a flatus tube, which is retained for the first few days. Urinary secretion is encouraged by intravenous infusions of glucose and saline, begun during the operation. Reactionary oedema of the terminal opening of the divided ureter within the lumen of the bowel may lead to post-operative anuria. In such circumstances sodium sulphate solution (4·285 per cent.) may be given with caution in order to promote diuresis If anuria persists when a healthy ureter has been transplanted, a nephrostomy should be performed when the kidney is enlarged and tender.

The left ureter may be transplanted similarly by a transperitoneal approach Care is necessary in identifying the ureter as it passes under the pelvic mesocolon from abnormally large para-ureteral or ovarian veins, which may closely resemble it The possibility of

tumours situated on the lateral wall of the bladder. The ureter is usually involved The bladder is exposed by a midline suprapubic incision and the peritoneal reflection stripped upwards and laterally. The area of the bladder involved may be estimated by extravesical palpation of its wall The bladder is opened through healthy tissue, and the area of tumour growth demarcated by tissue forceps. Vesical vessels are secured at the margin of the involved area. When the ureter is involved it must be divided immediately above the diseased area and preserved The portion of bladder wall and the tumour are removed en bloc, with a margin of healthy tissue as outlined by the tissue forceps. Bleeding vessels are caught and ligated. The ureter is re-implanted into the bladder without tension through the incision A fine catgut suture may be used to secure the ureter to the vesical mucosa; and one or two traction sutures may be inserted between the adventitia of the ureter and the vesical fascia The wound in the bladder is closed by interrupted sutures around a drain, care being taken to avoid tension on the ureter. A large extravesical drain is passed down to the site of implantation of the ureter Suction is applied through the vesical drain and the bladder is kept empty and contracted in the post-operative period.

Total Cystectomy.—This operation has a limited field in the treatment of extensive malignant tumours of the bladder, but may be indicated in the presence of intolerable pain from bladder spasm Multiple simple papillomata which have become too numerous for endoscopic treatment present a problem from recurring haemorrhages which can be met only by cystectomy. Epidermoid carcinoma is infiltrative from the beginning, and accordingly when this tumour occurs on the bladder base or trigone extirpation of the bladder offers the only chance of cure. The operation is carried out in two or more stages: (1) deviation of the urinary stream, and (2) removal of the bladder

Deviation of the urinary stream is most satisfactorily carried out by *intra-sigmoid transplantation of the ureters.* Owing to the frequency with which post-operative anuria or pyelonephritis endangers life when transplantation of both ureters is carried out at one sitting, the operation is usually done in two stages with an interval of ten days or more between The right ureter is dealt with at the first operation, when the general peritoneal cavity is examined for evidence of secondary malignant invasion. Spinal anaesthesia is the method of choice, and the patient is placed with the head and shoulders slightly lowered. The peritoneal cavity is opened by a sub-umbilical paramedian incision and the intestines are packed off. The recto-vesical pouch is examined for evidence of peritoneal involvement, and the bifurcation of the aorta is identified. The ureter is sought

CHAPTER XXXII

OPERATIONS ON THE URETHRA

Anatomy. Traumatic Rupture. Extravasation of Urine. Calculus. Foreign Bodies. Prostatic Abscess. Stricture. Epispadias. Hypospadias.

Anatomy.—In the male the urethra averages about 20 cm. (8 in.) in length. That portion of the canal which extends from the meatus to the opening in the urogenital diaphragm (triangular ligament), a distance of about 15 cm. (6 in.), is spoken of as the *anterior urethra*. It is surrounded by the elastic erectile

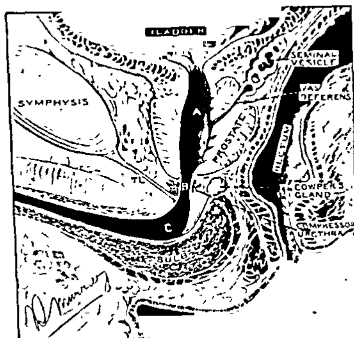


Fig. 227 Diagram of Male Urethra

A, Prostatic: *B*, Membranous: *C*, Bulbous Urethra, *T.L*, Anterior Layer of Triangular Ligament (perineal membrane).

tissue of the corpus spongiosum penis and consists of four parts. navicular, penile, scrotal, and bulbous. The navicular portion, which corresponds to the glans penis, is contracted at its junction with the pen[illegible]

[illegible] the roof The penile portion is the most mobile; it varies in length and, being superficial, it is readily palpated through the skin on the under aspect of the penis, particularly when there is a stricture or when a stone or foreign body is lodged in its lumen. The scrotal portion is deeper and more fixed than the preceding portions, but is easily palpated when an instrument is passed into it The bulbous portion (Fig. 227) is surrounded by the expanded posterior end of the corpus spongiosum penis, and is fixed to the anterior surface of the

double ureter must not be overlooked if the ureter exposed appears unduly small The site of implantation into the colon is proximal to that of the right ureter, and again care is taken to ensure absence of tension. In many cases it is of advantage to approach the ureters extraperitoneally from muscle-splitting incisions in the iliac fossae. The ureter may thus be identified in its entirety before opening the posterior parietal peritoneum. The pelvic colon is readily identified and transplantation carried out with a technique similar to that described above

Removal of the Bladder.—Following successful deviation of the urinary stream, total cystectomy may be carried out. Access is obtained by a midline suprapubic incision. The peritoneal covering of the bladder is stripped completely and the bladder mobilized anteriorly. By dissection the rectum is freed from the posterior lobe of the prostate The vesical vessels and vas deferens are ligated and divided on each side Anteriorly the pubo-prostatic ligament is ligated and divided. The urethra is cut just in front of the apex of the prostate, which is now drawn forwards and gently separated from the rectum The bladder is removed and the cavity is packed with gauze to control oozing The wound is loosely closed with interrupted sutures, ample space for drainage being provided. The pelvis may also be drained through the perineum.

Operation for Vesical Exstrophy.—Plastic operations for this condition have been completely superseded by implantation of both ureters into the bowel (p. 499).

D. B.

CHAPTER XXXII

OPERATIONS ON THE URETHRA

Anatomy. Traumatic Rupture. Extravasation of Urine. Calculus. Foreign Bodies. Prostatic Abscess. Stricture. Epispadias. Hypospadias.

Anatomy.—In the male the urethra averages about 20 cm. (8 in.) in length. That portion of the canal which extends from the meatus to the opening in the urogenital diaphragm (triangular ligament), a distance of about 15 cm. (6 in.), is spoken of as the *anterior urethra*. It is surrounded by the elastic erectile

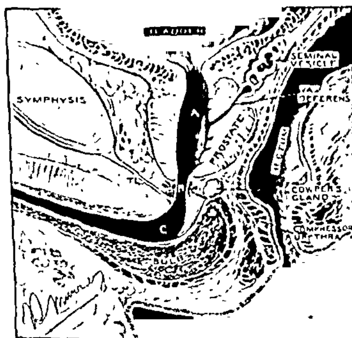


Fig. 227. Diagram of Male Urethra.
A, Prostatic; *B*, Membranous *C*, Bulbous Urethra, *T L*, Anterior Layer of Triangular Ligament (perineal membrane)

tissue of the corpus spongiosum penis and consists of four parts: navicular, penile, scrotal, and bulbous. The navicular portion, which corresponds to the *glans penis*, is contracted at its junction with the penile portion, and also at the meatus, which is the narrowest portion of the entire urethra. In passing a fine instrument along this portion, the point should be kept in contact with the floor to prevent it entering any of the pit-like recesses which are present in the roof. The penile portion is the most mobile; it varies in length and, being superficial, it is readily palpated through the skin on the under aspect of the penis, particularly when there is a stricture or when a stone or foreign body is lodged in its lumen. The scrotal portion is deeper and more fixed than the preceding portions, but is easily palpated when an instrument is passed into it. The bulbous portion (Fig. 227) is surrounded by the expanded posterior end of the corpus spongiosum penis, and is fixed to the anterior surface of the

perineal membrane. It is the most dependent part of the urethra, is about 1 25 cm (½ in.) in length, and is roomy and distensible; it cannot be palpated from the perineum unless a rigid instrument has been passed, or its walls are indurated by fibrous tissue. It is the commonest seat of gonorrhoeal stricture, and also of stricture resulting from a fall on the perineum. The junction of the anterior with the posterior urethra is represented by the opening in the perineal membrane, the most fixed, and, next to the meatus, the narrowest part of the entire tube. In passing an instrument through it, the point must be kept in contact with the roof of the canal and the handle depressed as soon as the resistance of the perineal membrane is encountered. False passages usually perforate the floor of the urethra at this point (Fig. 227).

The **posterior** or **deep urethra** comprises the membranous and prostatic portions. The membranous urethra lies about 2·5 cm. (1 in.) below the lower border of the symphysis between the two layers of the perineal membrane, it is about 1 5 cm (½ in.) long, and is surrounded by the sphincter urethrae (compressor)—the 'shut-off' muscle—which, when spasmodically contracted, may prevent the passage of a soft catheter An instrument in the membranous urethra is easily felt from the rectum immediately distal to the prostate. The prostatic urethra—3 cm. (1¼ in) in length—is the widest and most distensible portion of the tube; in the erect posture its direction is almost vertical, with a slight curve concave towards the pubes, the mucous membrane is extremely sensitive, and when it is irritated the nerve mechanism of micturition is greatly disturbed.

The urethra is lubricated by the secretion of the glands of the prostate and seminal vesicles, which open into the prostatic urethra, of Cowper's glands, which lie between the two layers of the perineal membrane and open into the floor of the bulbous portion, and of numerous minute mucous glands opening into the penile urethra. All these glands become more active during sexual excitement, and their secretion provides most of the seminal fluid.

Traumatic Rupture of the Urethra.—The usual sites of rupture are in the bulbous urethra in front of the perineal membrane, and in the posterior urethra at the apex of the prostate. The latter is associated with fracture of the pelvis, and gives rise to early extravasation of urine Treatment varies with the site of rupture, the permeability of the urethra, and the degree of extravasation

Rupture of the Bulbous Urethra without Extravasation of Urine.—If rupture is diagnosed early, the usual practice is to pass a soft rubber catheter (No 9 or 10 English) along the urethra and, if this succeeds, *to tie it into the bladder Sometimes stiffening of the catheter by means of a fine metal bougie and the use of a general anaesthetic* may allow of its being passed If there is a large perineal haematoma it should be incised.

If an instrument cannot be passed into the bladder, there is probably a complete rupture present with separation of the ends of the urethra. In these circumstances the bladder is opened by suprapubic cystotomy and the urethra is entered by 'the retrograde route' It should be ascertained that the patient's general condition is satisfactory and that there is no return of surgical shock before placing him in the lithotomy position. Bougies are now passed from

above through the internal meatus and from the external meatus to the site of rupture. An incision is made in the perineum and the urethra identified in the contused tissues by means of the sound. As the membranous layer of the superficial fascia of the perineum is incised there will possibly be an escape of extravasated urine as well as of blood. The tip of the bougie from the external meatus enables the distal end of the divided urethra to be identified, and the tip of the bougie passed from the bladder acts as a guide to the proximal stump of the urethra. Without preliminary cystostomy and the passage of the retrograde bougie much valuable time may be lost in a vain search for the divided urethra which has retracted amongst lacerated or contused tissues. The distal bougie is now withdrawn and replaced by a rubber whistle-tipped catheter, which is fitted over the end of the proximal bougie and drawn into the bladder. The two ends of the torn urethra are approximated over the catheter and its roof is approximated by a few interrupted sutures of fine catgut. The floor of the urethra is left open for drainage. Additional rubber dam tissue drains are inserted in the wound, which is insufflated with sulphonamide and penicillin powder. The skin edges are approximated with a few interrupted sutures. The patient is now restored to the dorsal position. A linen thread is passed through the eye of the catheter and tied to a glass rod secured to the abdominal wall. A suprapubic self-retaining catheter is left in the bladder for a few days as a further safeguard against extravasation.

Should the patient's general condition not permit of the change to the lithotomy position, retrograde catheterization may be accomplished by making the two bougies meet in the perineum. The tips are maintained in contact by 'sounding' and the penile bougie is thus guided into the bladder. The open end of the rubber catheter is now fitted over the tip of the bougie which is withdrawn to the exte [illegible]
it. [illegible]
guai [illegible]
The membranous layer of the superficial fascia of the perineum should be incised to permit of the free drainage of extravasated blood and possibly of urine

The alternative to the above method is to pass a bougie along the anterior urethra to the site of rupture, carry out external urethrotomy, and search in the perineal wound with a probe for the proximal end of the urethra Great difficulty is frequently experienced in finding the urethra in the contused tissues, and eventually the retrograde method may have to be adopted After an injury to the urethra it is important to maintain the canal fully dilated by the

regular passage of bougies. Post-traumatic stricture formation is common.

Rupture of the Posterior Urethra at the Apex of the Prostate.—Special difficulty is experienced with this type of rupture owing to the degree of shock accompanying it. The perineal membrane usually remains intact so that a haematoma forms and later extravasation of urine occurs in the prevesical space above, and in the pelvic cellular tissue lateral and posterior to the neck of the bladder. When the pubo-prostatic ligament has been ruptured, the prostatic urethra becomes displaced backwards and upwards. This displacement, the formation of a haematoma, and later extravasation of urine lead to a considerable separation between the torn ends of the urethra. When there is a fracture of the pelvis it is not advisable to place the patient in the lithotomy position in case displacement of the fragments of bone may lead to further complications, including additional shock. In *incomplete rupture* a rubber catheter should be passed *per urethram* and tied in position. The lower abdominal wall should be watched for any evidence of extravasation or deep cellulitis; if this occurs the prevesical space should be opened and drained, accompanied, if necessary, by through-and-through drainage to the perineum. The administration of sulphonamide drugs and penicillin is essential during the after-treatment, until normal micturition has been restored and any tendency to infection overcome.

In *complete rupture of the posterior urethra* at this level anti-shock treatment is necessary before an operation can be contemplated. In the presence of a fracture of the pelvis the patient must be handled with care A suprapubic incision is made and extravasated blood, and possibly a little urine, will be observed in the prevesical space. The finger is passed round this space and to the lateral aspects of the prostatic urethra, removing blood clot. If the haematoma has burrowed to the perineum, counter-drainage is recommended The prostatic urethra has become displaced backwards and the bladder may contain urine After opening the bladder at its highest point two bougies are passed, the one retrograde from the bladder, the other from the external meatus. It is usually easy to make the two tips meet in the haematoma space surrounding the site of rupture of the urethra, and thereafter to guide the distal bougie by sound and touch through the proximal urethra into the bladder. Although simple retrograde catheterization may be done now in order to splint the urethra, the separation of the torn ends may persist owing to the elasticity of the urethra and the displacement upwards and backwards. A Foley type of catheter with a small balloon, to be distended with 10 to 15 c.c. of water, may be passed by securing its eye to an ordinary whistle-tipped catheter which is pulled through, or by

guiding it through the ruptured site by a thread withdrawn down the urethra as the external bougie is removed. Sometimes the balloon catheter may be guided by vision into the prostatic urethra, through the retropubic space which has been opened up and illuminated by a malleable lamp. With the balloon distended with water, traction can be brought to bear on the prostatic urethra through the catheter, which is fixed to the thigh by strapping under tension. The close approximation of the ruptured ends of the urethra and the correction of the posterior displacement lead to accurate union and restoration of the continuity of the urethra with little scarring. It is essential to drain the bladder suprapubically to prevent further extravasation, and to control infection by sulphonamide and penicillin insufflations into the prevesical space. If the haematoma has extended to the perineum, counter-drainage should be provided by a small drain of corrugated rubber. Oozing in the retropubic space may be controlled by inserting two or three cigarette drains, the first of which should be removed the day following the operation in order to hasten the obliteration of the cavity in the cellular tissue. During the post-operative period sulphonamide and penicillin therapy are maintained until normal micturition is restored. The urethral balloon catheter may be replaced at the end of one week by an ordinary Marion catheter, and the suprapubic self-retaining catheter is then removed.

Although stricture is not common in this type of rupture, an uncorrected displacement of the posterior urethra leads to an angulation of the urethra which is difficult to negotiate with a bougie. Regular instrumentation is necessary at follow-up examinations.

Rupture of the Urethra with Extravasation of Urine.—In rupture at the common site—in front of, or through the anterior layer of the perineal membrane—the urine infiltrates the cellular tissue of the anterior part of the perineum, the scrotum, the penis, the groins, and the anterior abdominal wall.

In rupture involving the posterior urethra, the urine fills up the compartment between the two layers of the perineal membrane, and then spreads forwards or backwards according to the layer which has been torn along with the urethra. If the posterior layer is torn, the urine accumulates in the cellular tissue round the neck of the bladder and spreads upwards into the prevesical space and on to the anterior abdominal wall between the fascia transversalis and the parietal peritoneum.

In such cases suture of the urethra is impossible, and a catheter should be passed by the retrograde method.

Multiple incisions are then made into the tissues in which urine has been extravasated. Urine and inflammatory exudate ooze from

the wounds, but there is seldom any bleeding that requires ligation of vessels. After the cellular tissue has been irrigated with warm saline solution, the wounds are insufflated with penicillin and sulphanilamide powder and lightly packed with gauze.

Calculus impacted in the Urethra.—If the stone is lodged in the *navicular fossa*, the meatus is slit downwards and the stone squeezed out or hooked forwards with a bent scoop or director.

When the stone is in the *penile portion* an attempt may be made, after anaesthetizing the mucous membrane, to extract it with urethral forceps, but as this is liable to damage the mucous membrane and to lead to the formation of stricture, it is safer and more certain to make a longitudinal incision through the floor of the urethra directly over the stone. The wound in the urethra usually heals spontaneously without the formation of a urinary fistula.

A stone impacted in the *posterior urethra* should be cut down upon in the perineum

Foreign Bodies in the Urethra.—Foreign bodies, such as a pencil, a straw, or a hat-pin, introduced by the meatus, usually lodge in the penile portion of the urethra They are best removed by cutting down on the under aspect of the urethra. A simple means of removing a hat-pin is to push the sharp point through the floor of the urethra, and to pull on the pin till it is arrested by its head. The head is then pushed distally along the urethra till it emerges at the meatus, when the whole pin is withdrawn.

Abscess of the Prostate.—A general anaesthetic is administered, a staff is passed into the bladder, and the patient placed in the lithotomy position The dissection is similar to that employed to expose the prostate in the operation of perineal prostatectomy (p 520) Both lobes of the prostate are exposed and separate incisions are made into them, after which the finger is introduced and all septa are broken down. Drainage is provided by introducing one or more strips of rubber dam through the perineal wound, which is loosely closed.

Treatment of Stricture of the Urethra

Intermittent Dilatation.—The object of this procedure is gradually to overstretch the scar-tissue in the wall of the urethra and so to re-establish the calibre of the canal. Care must be taken not to overdo the stretching at any one sitting, otherwise inflammatory reaction is set up which may defeat the object aimed at. The utmost care and gentleness must be exercised, and the instrument must never be passed against resistance until the surgeon is satisfied that the point is engaged in the stricture and is grasped by it. Even then the amount of force employed must be slight. If the point of

the bougie catches in the mucous membrane it should be withdrawn a short distance and then passed again, the urethra being kept on the stretch by making traction on the penis.

Before passing instruments, the glans and meatus are cleansed with an antiseptic lotion. If the urethra is sensitive and congested, a solution of eucain and adrenaline may be injected into the canal. It is sometimes found that instruments pass more easily if the anterior urethra is distended with sterilized oil or glycerine. A urethral nozzle of acorn shape fitted to the syringe makes it possible to distend the urethra. All the instruments likely to be required are placed on a sterile towel in the order in which they are to be used. Metal instruments should be warmed to body temperature by being dipped in sterilized water before being introduced, and smeared with a sterile lubricant.

At the first sitting, before the site and disposition of the stricture have been determined, a medium-sized bougie, say No. 6 (English) of the Lister or Chiene type, is first introduced. If it is arrested, the position of the stricture is noted and its distance from the meatus measured. Further information may be gathered regarding the nature of the stricture by feeling for the point of the instrument through the perineum or with a finger in the rectum. A short narrow thickening of the urethral wall just beyond the point of the instrument indicates a 'bridle' stricture; a long irregular thickening usually means a tortuous and irregular one.

The No. 6 is now withdrawn and a No. 5 passed; if it also is arrested, smaller and smaller instruments are tried until one engages in the stricture. If it is found that not even the smallest of the metal instruments will engage, fine filiform instruments, made of whalebone, gum-elastic, or horsehair, may be tried.

We have found the metal instrument devised by A. G. Miller useful for entering and stretching a narrow stricture. It has a fine point (No 0 or No. 1) and rapidly expands to a full size. The handle is made large and heavy so that the weight of the instrument tends to carry it on if it is merely guided by the surgeon. In practised hands this instrument is most helpful, but we do not recommend its use to the beginner.

Once the stricture has been entered and negotiated, it is further dilated by passing two or three larger sizes. The patient is then put to bed and a hot drink and a short course of sulphathiazole given to prevent rigors. A note should be made of the instruments passed.

After three or four days further dilatation is carried out, beginning with the middle number of the series used at the previous sitting, and passing three or four higher numbers. This is repeated at intervals of three or four days until a full-sized instrument—say

the wounds, but there is seldom any bleeding that requires ligation of vessels. After the cellular tissue has been irrigated with warm saline solution, the wounds are insufflated with penicillin and sulphanilamide powder and lightly packed with gauze.

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freely slit up so as to get rid of all pockets in the perineum, and if the walls of the tracks are dense and fibrous they may be excised. At the same time Syme's operation of external urethrotomy is performed.

A small fistula in the penile urethra, following the rupture of a peri-urethral abscess, may be excised and the edges of the opening in the urethra sutured over a catheter, which is left in position until healing takes place.



FIG 228. Radiograph of Urethra showing Multiple False Passages.

If a considerable portion of the urethral wall has been lost, a plastic operation is required.

These conditions often prove very intractable, but great help is obtained by diverting the urine: an opening into the bladder is made above the pubes and a self-retaining catheter is inserted and connected with a suction apparatus.

Internal Urethrotomy.—This operation, which consists in dividing a stricture by means of a guarded knife or urethrotome passed along the urethra, is useful only in valvular and 'bridle' strictures of the penile portion which are so resilient that they rapidly contract again after being dilated with bougies It is not recommended when sepsis is present.

CONGENITAL DEFORMITIES

Epispadias.—In this condition the roof of the urethra is deficient, an extreme degree being represented by extroversion of the bladder. In minor degrees of the condition, in which sphincter control of the bladder is present, and the urethra forms a groove on the dorsum of the penis, a roof may be provided by a plastic operation.

No. 15—can be passed. Owing to the tendency of the stricture to contract, instruments should be passed at regular intervals, beginning with once a fortnight and gradually lengthening till once in six months or even once a year may suffice.

External Urethrotomy.—This operation is called for in cases of stricture of the urethra in which instrumental dilatation has become increasingly difficult It is indicated when there have been complications such as peri-urethral cellulitis or fistula.

If the stricture is permeable, a Syme's staff is passed along the urethra until the shoulder of the instrument rests against the stricture. The patient is now placed in the lithotomy position, and an incision is made in the middle line of the perineum, dividing the urethra and exposing the groove in the staff; the stricture is then divided by directing the knife along the groove forwards until the shoulder of the staff is exposed.

If the stricture is impermeable, a *Wheelhouse's staff* is passed down the urethra until it is arrested, the bulbous end of the instrument is cut down upon and the urethra opened in front of, that is, distal to, the stricture The edges of the incision in the urethra being held aside, the lumen of the stricture is sought for with the help of a probe or director. The stricture is then divided

In the absence of infection, a rubber catheter is passed from the meatus into the bladder and tied in, after which the tissues divided in the perineum are brought together with successive tiers of catgut sutures When there is infection the wound must be left open, and the bladder drained by a catheter inserted through the urethra posterior to the site of the divided stricture

In cases of annular stricture the stenosed portion of the urethra may be resected. The method described by Hamilton Russell has given good results: after resection of the stricture, the roof of the urethra is united by interrupted catgut sutures, a catheter being passed into the bladder through the floor of the urethra, which is left open The catheter is soon removed and the urethral fistula thereafter closes.

In cases of extravasation of urine resulting from the rupture of a peri-urethral abscess associated with stricture of the urethra, external urethrotomy is indicated to allow of drainage of the bladder and to stop leakage of urine Under general anaesthesia a bougie can usually be guided past the stricture and the urethra is opened posterior to the stricture, the abscess being opened simultaneously. A catheter is passed from the perineum into the bladder and multiple incisions are made into the infiltrated tissues, as for extravasation associated with traumatic rupture of the urethra (p. 529).

Multiple Perineal Fistulae associated with stricture must be

In Thiersch's operation the roof is provided by a local penile flap, the raw surface of the flap and of the donor site being covered by

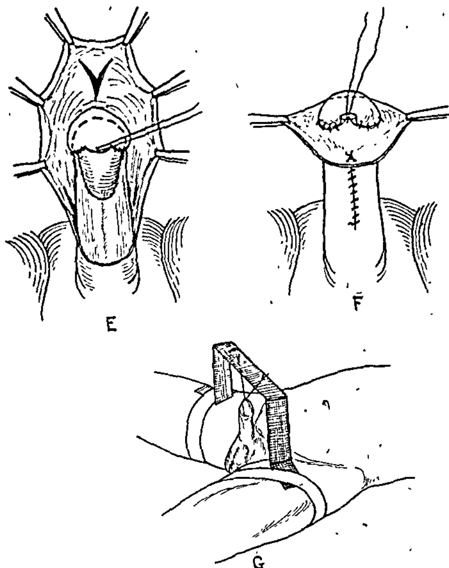
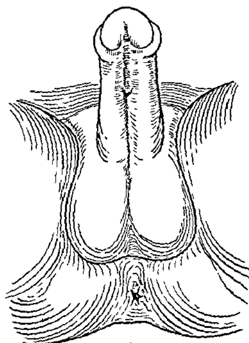


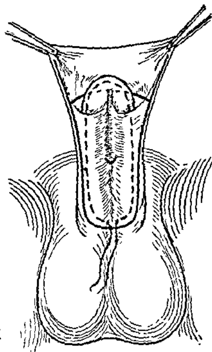
FIG 230. Ombrédanne's Operation for Hypospadias (1st Stage continued.)

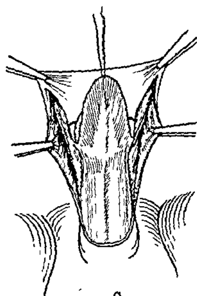
E Y-shaped incision made in preputial flap to allow glans to be passed through
F Final outer covering of urethral flap with preputial skin.
G Penis suspended to wire bridge for ten days

a flap from the opposite side of the organ The urethra so constituted lies on the dorsal aspect of the penis

When the condition is associated with incontinence of urine, the ureters may be transplanted to the colon (p. 524)







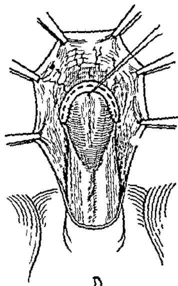


FIG 229. Ombrédanne's Operation for Hypospadias (1st Stage.)

A Penile hypospadias
B Insertion of purse-string, and incision
C Urethral flap raised
D Preputial flap raised.

by threading the glans through a tri-radiate incision in the prepuce, and suturing the latter to the edges of the defect (Fig. 230). Three months later the urethral flap is approximated to the surface of the penis and glans (Fig. 231).

Macindoe's Method.—A special hollow introducer with separate bayonet point and handle is required. A rubber tube of smaller external calibre than the internal calibre of the introducer is covered with a thick razor graft, deep surface outwards, which is secured by a few stitches, and the tube inserted into the introducer. The bayonet point and handle are attached. Through a small skin incision the point is inserted immediately distal to the abnormal meatus, and made to emerge at the tip of the glans. The bayonet point is detached, the rubber tube with the graft secured, and the introducer withdrawn. Ten days later the rubber tube is removed, and replaced at once by a special gum elastic dilator, which remains continuously in position for six months. Thereafter the penile fistula is closed by separation of its mucous and cutaneous edges, and sutured in two layers.

D. B.

Hypospadias.—In this condition the floor of the urethra is deficient. The glandular type, in which the urethra opens at the posterior margin of the glans, does not require operative treatment other than dilatation of the meatus if necessary.

When the opening is in the penile urethra, the first step in operative treatment is to correct the ventral curve of the penis resulting from hypoplasia or sclerosis of the corpus spongiosum penis. This should be done when the child is about three years old A transverse

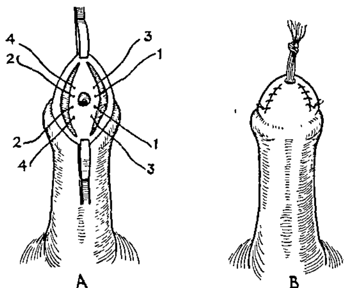


Fig. 231. Ombrédanne's Operation for Hypospadias (2nd Stage) (2 months later)

A Rawing of edges, stitches inserted
B Stitching completed, ends brought through meatus and knotted together

incision is made immediately distal to the urethral opening, and is deepened to expose the sclerotic corpus spongiosum and the septum between the corpora cavernosa All constricting tissue is divided and the remains of the corpus spongiosum are excised. The penis is straightened, the skin wound is sutured vertically, and the organ is strapped or stitched to the anterior abdominal wall over a small gauze pad.

A year or two later the remaining steps of the repair are completed.

Ombrédanne's Method—A floor is provided for the urethra by swinging distally a flap raised from the under surface of the penis proximal to the abnormal meatal opening (Fig. 229) The incisions for this flap are continued distally round the corona, and on to the hood-like prepuce, to permit of the layers of the latter being separated to form a single layer of skin (Fig 229 D). The raw areas left on each side of the floor, and the under surface of the urethral flap are covered

with the part supported. The first step in the operation consists in isolating the penis and testes by dissection, and folding them up over the pubes. With the scrotal swelling suspended in the air an elastic tourniquet is applied at its base, and the mass of tissue removed with a large amputating knife. After the bleeding has been arrested the testes are replaced and the skin brought over them and sutured.

Tumours of the Scrotum.—*Non-malignant Tumours and Cysts* are excised on the same lines as similar growths of the skin elsewhere. *Epithelioma*, particularly the paraffin type, is the most common malignant tumour met with. The growth with a considerable area of the skin around it is excised, and it is necessary to remove the associated lymph glands from both groins.

The Testis, Epididymis, and Spermatic Cord

Anatomy.—The *testis* is enclosed in a firm, fibrous capsule—the tunica albuginea—which is specially thick and strong at the posterior part. The spermatozoa leave the testis by the efferent ductules and enter the *epididymis*, which is composed of a highly convoluted tube, the coils of which are bound together by dense connective tissue. It lies on the posterior aspect of the body of the testis, and is divisible into three portions: an upper broad, rounded portion—the head; a narrower, intermediate portion—the body; and a lower, pointed portion—the tail.

The *vas deferens*, the excretory duct of the testis, passes from the globus minor along the back of the testis and to the medial side of the epididymis. It joins the other elements of the spermatic cord, and, after traversing the inguinal canal and entering the deep inguinal ring, turns downwards into the pelvis After running along the posterior surface of the bladder, it reaches the base of the prostate gland and is there joined by the duct from the corresponding seminal vesicle, the two forming the *common ejaculatory duct*, which, after traversing the prostate gland, opens into the floor of the prostatic urethra

The *spermatic cord* extends from the testis to the deep inguinal ring. It is made up of the vas deferens, which lies posteriorly and is accompanied by the small artery to the vas, the testicular artery, which lies in front of the duct, and the artery to the cremaster, which ramifies in the superficial structures of the cord. The veins of the cord are arranged in two bundles, the larger of which—*the pampiniform plexus*—accompanies the testicular artery, while the smaller lies farther back and accompanies the artery to the duct

The cord also
from the symp
glands These
tissue, and are enclosed in the coverings of the cord.

The *coverings of the testis and cord* are derived from the layers of the abdominal wall during the transit of the testis: the *external spermatic fascia*, a fibrous sheath prolonged from the edges of the superficial abdominal ring; the *cremaster muscle and fascia* composed of loops of muscular tissue prolonged from the lower, free edge of the internal oblique; and the *internal spermatic fascia*, a funnel-shaped process continuous with the margins of the deep inguinal ring

The *tunica vaginalis testis* is a serous sac intervening between the anterior aspect of the testis and the scrotal wall

CHAPTER XXXIII

OPERATIONS ON THE MALE GENITAL ORGANS

Anatomy. Cellulitis. Elephantiasis and Tumours of Scrotum. Ectopia Testis Torsion of Cord. Varicocele. Vasectomy Hydrocele. Castration. Epididymectomy. Excision of Seminal Vesicle. Circumcision Amputation of Penis.

THE SCROTUM

Anatomy.—The *skin* of the scrotum contains numerous sebaceous glands. In the superficial fascia, which is devoid of fat, is a layer of muscular tissue—the *dartos* muscle—which when contracted diminishes the size of the scrotum and throws the skin into a series of horizontal rugae The scrotum is capable of being stretched to a remarkable extent, for example, by a hernia or a hydrocele, but when the contents are removed, it rapidly contracts again to normal proportions, and it is seldom necessary to excise any portion of the apparently redundant skin. Under the dartos is a layer of open, vascular areolar tissue in which effused blood or serum may collect in large quantities, causing great swelling The lymphatics of the scrotum empty into the glands in the groin

Incisions in the Scrotum.—Owing to the rugose nature of the skin of the scrotum and to the fact that it is peculiarly sensitive to the irritant action of antiseptics, it is difficult to obtain a sufficient degree of asepsis to ensure primary union. It is, therefore, desirable to avoid carrying incisions into the scrotal tissues if the purpose of an operation can be attained without doing so. Further, as incised wounds of the scrotum are liable to be followed by reactionary haemorrhage, it is necessary to secure every bleeding-point by ligature before closing the wound, and to make firm pressure over the part by the dressing and bandage As the contraction of the dartos muscle tends to turn in the edges of the wound, in inserting sutures care must be taken to include the muscle and to evert the edges slightly; Michel's clips are useful for this purpose. It is usual to provide for drainage in scrotal wounds

Cellulitis and Gangrene of the Scrotum, which usually result from periurethral cellulitis and extravasation of urine following stricture of the urethra or from infection of surface wounds, call for free longitudinal incisions into the affected areas Sloughs may be clipped away with scissors as soon as a line of demarcation has formed The testes, which seldom share in the gangrene, are rapidly covered over by contraction of the resilient skin as cicatrization proceeds.

Elephantiasis of the Scrotum.—In extreme cases of elephantiasis it is sometimes advisable to remove the redundant tissue. The operation is one of considerable severity To diminish the size of the swelling as far as possible the patient is confined to bed for some days

in the superficial fascia are usually larger than normal and should be ligated. After its coverings have been divided longitudinally, the cord is hooked up with the finger and pulled upon until the testis appears in the wound. The vas deferens with its accompanying

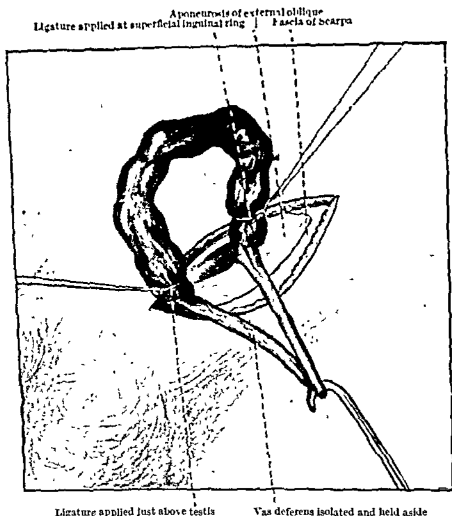


FIG. 232. Operation for Varicocele.

vessels, which lie on the posterior aspect of the cord, are then isolated and held aside with a strand of gauze or a blunt hook. The dilated veins of the pampiniform plexus are now defined at the superficial inguinal ring where they form several large trunks, and these are traced downwards as far as the upper pole of the testis, where they constitute a freely anastomosing plexus. The upper end of the bunch of veins thus isolated is secured at the superficial inguinal ring, and the lower end just above the epididymis (Fig. 232).

Operations for Ectopia Testis.—Orchidopexy.—An incision is made in the line of the inguinal canal about a finger's breadth above the inguinal ligament, exposing the superficial inguinal ring. The aponeurosis of the external oblique is slit up, and the testis exposed as it lies in the canal. The coverings of the cord are freely divided, and the relations of the testis to the vaginal process determined It is usually found that after the process has been freely divided the testis can be brought down to the bottom of the scrotum. If this is not possible, the vas deferens with its accompanying artery must be separated from the other constituents of the cord and held aside, and the spermatic vessels dissected upwards in the extra-peritoneal tissue for several inches. In some cases the testis cannot be brought down without division of the spermatic vessels, which gravely prejudices the further development and function of the testis With the finger, a bed for the testis is made in the scrotum. A chromic gut suture is now passed through the lower pole of the testis, including the tunica albuginea, and the two ends of the suture are brought out separately through the lowest part of the scrotum about 0·5 cm. ($\frac{1}{4}$ in) apart, and tied over a small piece of rubber tubing to avoid strangulation of the intervening portion of skin Fixation of the scrotum and testis to the skin of the thigh should be unnecessary

If, as is frequently the case, the incomplete descent of the testis is complicated by a hernia, the vaginal process, which has been divided in the course of the operation, must be obliterated at the highest accessible point in the canal

Torsion of the Spermatic Cord.—When the testis is imperfectly descended or when the upper part of the vaginal process is unobliterated, the spermatic cord is liable to become twisted on its long axis, occluding the blood-vessels and threatening the vitality of the testis

An incision is made over the swelling to expose the superficial inguinal ring The inguinal canal is laid open by slitting up its anterior wall—the aponeurosis of the external oblique—exposing the testis and cord If the testis is viable and in the scrotum, an attempt is made to undo the twist and to anchor the parts in such a way that recurrence cannot take place If this is found impossible, or if the testis shows signs of necrosis, it should be removed. After the vessels have been secured the upper part of the vaginal process is obliterated and the canal closed, as in the radical operation for hernia (p. 467).

Varicocele.—The cord is exposed as it emerges from the superficial inguinal ring by an incision a finger's breadth above and parallel to the medial third of the inguinal ligament The veins

lower and back part of the scrotum. A portion of the scrotal wall is selected which is free of veins and clear of the testis, and a small wheal of local anaesthetic raised. A fine trocar and cannula is thrust into the swelling in a backward and upward direction so as to avoid injuring the testis. After all the fluid has escaped, the puncture is sealed with collodion, the scrotum covered with cotton wool, and a

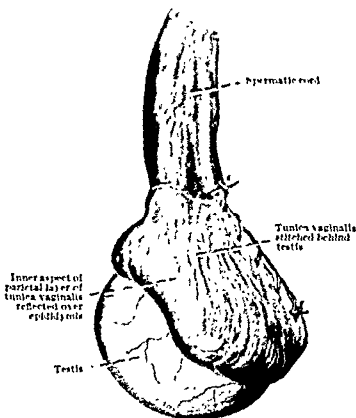


FIG. 233. Operation for Hydrocele by Winklemann's Method.

firm bandage applied to press the layers of the tunica vaginalis into apposition. The patient should rest in bed for some hours after the tapping.

The *injection* of sclerosing agents such as a few minims of pure carbolic acid into the sac is painful and less certain in its results than an open operation.

Open Operation.—Eversion of the sac is one method of treating hydrocele. The cord is exposed at the superficial inguinal ring by an incision similar to that made for castration, and after its coverings have been divided it is pulled upon until the upper end of the distended tunica vaginalis appears in the wound. The coverings of

The intermediate portion is removed, each bunch of veins being securely ligated by means of a Staffordshire knot. The ligatures are left long and are tied to one another, so that the ends of the divided veins are brought together, and the testis is suspended at a higher level in the scrotum. The duct and the vessels accompanying it, now relatively much longer than the stump of the divided veins, are replaced, the coverings of the cord are reunited by two or three points of suture, and the wound is closed without drainage. Only when the skin of the scrotum is exceptionally lax is it necessary to remove an elliptical portion of it.

Resection of Vas Deferens.—Vasectomy.—This simple operation is performed under local anaesthesia. The cord is grasped through the skin between the finger and the thumb, the duct defined, and a small incision made down upon the cord. The duct is withdrawn, an inch or two resected, and the ends allowed to slip back into the wound, which is then sutured.

End-to-end Suture of the Vas Deferens.—Vasorrhaphy.—An operation for uniting the vas deferens when it has been accidentally divided, say, in the course of an operation for hernia, has been devised by the brothers Mayo The ends of the divided duct having been isolated, a straight, round sewing-needle is inserted, eye first, into the lumen of one end, and the point is then introduced into the lumen of the other end After the point has passed for a distance of 3·5 cm. (1½ in) along the lumen, it is made to transfix the wall and protrude through it. The needle now acting as a temporary splint, the two ends of the duct are approximated to one another, and united by a series of fine silk or chromic gut sutures passed round the circumference of the junction A piece of connective tissue from the adjacent cord is stitched over these sutures to strengthen the union. The needle, having served its purpose as a splint, is then withdrawn.

Anastomosis of the Vas Deferens and Epididymis.—Vaso-epididymostomy.—In cases of occlusion of the vas deferens by cicatricial contraction following gonorrhoeal epididymitis, and after partial resection of the epididymis and duct, attempts have been made to re-establish the function of the tube by implanting the distal end of the divided duct in the parenchyma of the testis or, better, in the head of the epididymis

Hydrocele of the Tunica Vaginalis Testis.—*Tapping* —The patient either lies on a table or sits on the edge of a chair The surgeon grasps the scrotum at its upper end in such a way as to press all the fluid towards the lower and anterior part of the sac and to render it tense. The position of the testis is determined by palpation and by eliciting testicular sensation on pressing it it is usually found at the

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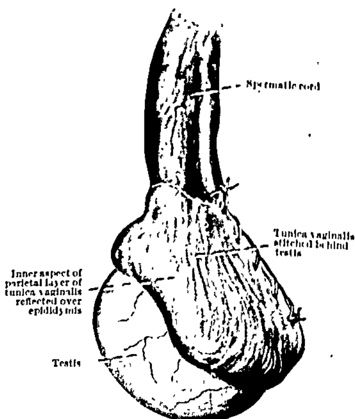


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vas deferens separated from the other constituents of the cord and divided, the vessels secured with forceps and tied separately, and the testis removed. If the cord is invaded by the disease, the inguinal canal is opened up by splitting the aponeurosis of the external oblique, and the constituents secured at the deep inguinal ring. A tuberculous vas deferens may be traced farther along the lateral wall of the pelvis. The canal is then repaired and the superficial ring closed. If it is considered advisable to drain the wound, the tube should be inserted through a small opening made at the lowest part of the scrotum.

When the scrotum is involved, and particularly when there are sinuses or a fungus testis, the affected portion must be included between semilunar incisions, and the ellipse of skin removed along with the testis.

When the operation is performed for malignant disease, the incision should be extended sufficiently in the abdominal wall to admit of the lymph vessels and iliac and lumbar glands being removed along with the testis in one piece, on the same principle as in removing the breast and axillary contents for cancer.

Epididymectomy.—When tuberculous disease is strictly confined to the epididymis, and particularly when the other testis has already been removed, resection of the epididymis alone may be carried out. The cord is exposed through an inguinal incision, and the testis withdrawn through the wound and examined. If it is found that the disease is confined to the epididymis, the reflection of the tunica vaginalis at the lower pole of the tail is snipped through with scissors, and the epididymis is separated from the body of the testis. When the head is reached, the vas deferens is separated from its accompanying vessels and cut across just above the upper border of the testis. The reflection of the tunica vaginalis on the head of the epididymis is then divided with scissors, and the separation of the epididymis from the testis is completed. The vessels supplying the testis, which enter the gland at its upper and medial aspect, are carefully preserved. To make certain that there is no disease in the body of the testis, an incision should be made along its posterior aspect. If a limited focus is discovered, it may be resected, but if the disease is extensive the whole testis must be sacrificed.

Excision of the Seminal Vesicle.—In cases of tuberculosis, in which the disease has spread to the vas deferens and the seminal vesicle, these structures may be removed as well as the testis.

The vas deferens can be exposed as far as the deep inguinal ring by opening up the inguinal canal; and by enlarging the deep ring laterally it can be traced to the base of the bladder. The seminal

the cord are slit open until the tunica vaginalis is clearly exposed. The tense wall of the hydrocele is then picked up with two pairs of Kocher's artery forceps, and a puncture is made between them with a trocar and cannula or a knife. As the fluid escapes, the forceps are pulled upon and the collapsed sac, together with the testis, is withdrawn from the scrotum. The parietal layer of the tunica vaginalis is then slit longitudinally from end to end, the two halves folded back till they meet behind the epididymis and cord, and the cut edges united in this position by a continuous catgut suture (Fig. 233). In this way the tunica vaginalis is turned inside out. All bleeding-points are then secured with ligatures and the testis returned to the scrotum. A small drainage tube is introduced through a puncture made for the purpose at the bottom of the scrotum, the inguinal incision completely closed, and firm pressure exerted on the scrotum by means of wool and a bandage.

Total Excision of the Sac.—After the tunica vaginalis has been exposed and slit longitudinally, it is trimmed close to the testicle, only a small fringe being left. A considerable number of bleeding-points require to be ligated. There may be oozing from the cut margin where this is thickened, as in chronic hydrocele. After the individual vessels have been clamped and ligated it is advisable to suture the entire cut margin with a running interlocking stitch of fine, plain catgut. When the bleeding is entirely controlled the testicle may be returned to the scrotum. Because of the danger of haematoma formation in the scrotum, it is advisable to place a small strip of dental rubber down to the lower pole of the testicle and bring it out at the lower angle of the wound. Alternatively, a small drainage tube may be introduced at the lowest part of the scrotum. The wound is closed in the usual manner and a dressing applied, firm pressure being exerted in the scrotum by means of an adequate layer of cotton-wool and a bandage.

Hydrocele of the Cord and Spermatocele are treated either by tapping, or by an operation similar to that for hydrocele of the tunica vaginalis

Removal of the Testis.—Castration or Orchidectomy.—This operation is most frequently performed for tuberculous disease of the testis and epididymis, and for neoplasm It is sometimes called for in syphilitic disease with sinuses and for ectopia testis. If the skin of

of the cord are divided, and the spermatic cord exposed. The testis enclosed in the tunica vaginalis is pulled out of the scrotum, and the

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vesicle is best reached from the perineum through a curved incision in front of the rectum similar to that employed in perineal prostatectomy (p. 520).

The Penis

Anatomy.—The penis is composed of the *corpus cavernosum penis* (corpora cavernosa) which lies towards the dorsum, and the *corpus spongiosum penis* which occupies the groove on the ventral aspect and is traversed by the urethra. These different elements are composed of erectile tissue, and are enclosed by fibrous sheaths (Fig. 234). The conical end of the penis—the expanded anterior

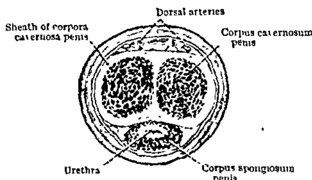


Fig. 234. Transverse Section of Penis.

end of the corpus spongiosum—is known as the *glans*, and the redundant fold of skin which covers it as the *prepuce*.

The *lymphatics of the external genitals* drain chiefly into the femoral and iliac glands.

Circumcision for Phimosis.—In adults circumcision can be performed under local anaesthesia, but in children a general anaesthetic is necessary.

Slitting of the Prepuce.—When the preputial orifice is narrow, but the prepuce not abnormally long or redundant, it is usually sufficient to slit the skin longitudinally along the dorsum. A broad flat director

is applied.

Removal of the Prepuce.—When the prepuce is abnormally long, the redundant portion must be removed. Adhesions between the lining membrane of the prepuce and the glans should be separated by retracting the prepuce as far as the corona. The prepuce is then pulled forward again, grasped in front of the glans with a pair of

dressing forceps applied obliquely from above downwards and forwards, and the portion in front of the blades of the forceps is cut off with a long bistoury. Care must be taken to remove just enough skin to enable the glans to be completely exposed, and yet to leave a covering for the sensitive papillae of the corona. After the forceps are removed, the lining membrane of the prepuce, which still covers

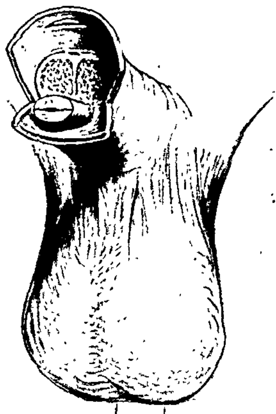


Fig. 235. Partial Amputation of the Penis.

the glans, is slit up along the dorsum, and the excess cut away with scissors. The bleeding is arrested by torsion, or with fine catgut ligatures, special attention being paid to the vessels in the vicinity of the frenum The cut edges of the outer and inner layers of the prepuce are then stitched together with interrupted sutures of fine catgut

Amputation of the Penis.—Partial Amputation.—A piece of rubber tubing is applied round the base of the penis to prevent haemorrhage, and a straight bougie passed down the urethra as far as the tourniquet will permit. A short flap of skin and subcutaneous tissue is then raised from the ventral aspect, well behind the malignant

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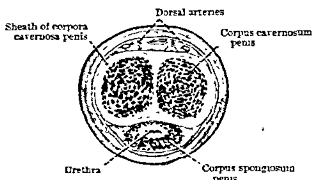


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growth, exposing the corpus spongiosum penis, which, together with the urethra, is divided by cutting down upon the bougie 2 cm. ($\frac{3}{4}$ in.) in front of the base of the flap (Fig 235). A flap of skin, sufficiently long to cover the end of the stump, is then reflected from the dorsal and lateral aspects of the penis, and the corpus cavernosum penis divided by a circular incision at the level of the base of the skin-flap. The tourniquet having been removed and the median dorsal vein with the dorsal arteries on each side having been secured, as well as any of the larger vessels in the corpus cavernosum that may bleed, a small opening is made in the dorsal flap opposite the level of the urethra, the end of which is slit up laterally for a short distance, pulled through this opening, and stitched to its edges Finally, the dorsal and ventral flaps are united by sutures.

Complete Amputation.—With the patient in the lithotomy position and a metal bougie in the urethra, a median incision is carried from the peno-scrotal junction to the mid-point of the perineum, splitting the scrotum and exposing the corpus spongiosum at the bulb When the perineal membrane is exposed, the bougie is withdrawn and the corpus spongiosum, which has been dissected out, is cut through, a sufficient stump being left to bring out in the perineum The crura are then traced backwards as far as their attachments to the rami of the pubes, and dissected off the bone. The structures on the dorsum are next divided by carrying an elliptical incision up to the symphysis, dividing the suspensory ligament and the dorsal vessels as they pierce the urogenital diaphragm

The penis having been removed, the stump of the urethra is fixed to the edges of the perineal wound, about 2·5 cm. (1 in.) in front of the anus, after which the two halves of the scrotum, containing the testes, are replaced and the skin sutured with horsehair. It is generally advised to remove the testes at the same time.

To ensure complete removal of the lymphatic connexions, the glands in front of the pubes, those accompanying the cord in the inguinal canal, and the superficial and deep inguinal glands on the medial side of the femoral vein must be dissected out on both sides. An incision is made over each inguinal canal, the aponeurosis of the external oblique slit up, and the lymph vessels accompanying the cord removed These two incisions are then united across the median line to afford access to the prepubic lymph glands From the original wound an incision is carried laterally on each side to expose the femoral triangle, from which the superficial and deep inguinal glands are cleared This may be done at the same time as the penis is amputated, or, as Butlin recommended, as a secondary operation No attempt should be made to remove the glands if they have broken down and infected the skin and cellular tissue. D. B.